DOCUMENT RESUME

ED 309 612	EC 220 757

AUTHOR	Billingsley, Felix F.
TITLE	SIRS: Investigation of the Relative Efficacy of Two Response Prompting Techniques in the Instruction of Students with Severe Handicaps. Final Report.
INSTITUTION	Washington Univ., Seattle.
SPONS AGENCY	Special Education Programs (ED/OSERS), Washington, DC.
PUB DATE	31 Dec 86
GRANT	G008302190
NOTE	145p.; Some graphs will not reproduce well.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC06 Plus Postage.
DESCRIPTORS	Adolescents; Comparative Analysis; *Instructional Effectiveness; Outcomes of Treatment; *Prompting; *Severe Disabilities; *Severe Mental Retardation; Time Factors (Learning); *Training Methods
IDENTIFIERS	*Graduated Guidance; *Time Delay

ABSTRACT

The study investigated the comparative effectiveness of the graduated guidance and time delay response prompting techniques when utilized as part of instructional interventions with students with severe disabilities. A replicated single subject, repeated measure design was used with seven subjects, aged 13-21. No significant differences were found between performance under time delay and graduated guidance treatments. Of the seven subjects, three showed no educationally significant progress under either experimental procedure. Acquisition and maintenance slopes for the remaining four subjects did not support the superiority of either experimental procedure. (JDD)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED309612

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Final Report

SIRS: Investigation of the Relative Efficacy of Two Response Prompting Techniques in the Instruction of Students With Severe Handicaps

Felix F. Billingsley, Principal Investigator

Grant # G008302190

December 31, 1986

EC220757

BEST COPY AVAILABLE

SIRS: Investigation of the Relative Efficacy of Two Response Prompting Techniques in the Instruction of Students with Severe Handicaps

Summary of Objectives:

The goal of this project was to investigate the comparative effectiveness of the graduated guidance and time delay response prompting techniques when utilized as part of instructional interventions with students with severe disabilities. Seven objectives were formulated to facilitate attaining the goal of the project. The seven objectives included: 1-identify the tasks for instruction; 2-identify the students to serve as subjects; 3-recruit and train project staff, 4-assign the tasks to the two treatment conditions; 5-conduct training sessions and collect performance data; 6-analyze performance data; and 7-prepare final report. The actual accomplishments under each of these objectives are discussed briefly below. Full details are provided in the complete study, which is included as Appendix A of this report.

Objective 1: Identify tasks for inclusion in the study

This objective entailed the analysis of the validity data from the Trainee Performance Sample, a vocational assessment instrument developed at the University of Oregon. Since this study compared the effects of two different treatments upon the acquisition of new skills in the subjects, tasks that were approximately equal in difficulty were necessary to rule out the potential confound of differential rates of acquisition being due to differences in task difficulty. Tasks from the Trainee Performance Sample were selected due to the availability of performance data from 149 subjects with moderate to severe disabilities. These data were analyzed to determine what tasks could be matched to form approximately equivalent pairs. These pairs were then subjected to rankings by raters with extensive experience in the education of persons with severe disabilities to determine if there was any significant tendency to rank either task in a pair as more difficult than the other. These analyses resulted in the formation of 10 pairs of items. Of these 10 pairs, 5 were judged to demonstrate approximately equivalent difficulty. Initial task selection was completed by 10/1/83, which was within the original timeline for this project.

Objective 2: Identify students to serve as subjects

The subjects for this study were drawn from 2 school districts in the Seattle, Washington area. Parental consent for the participation of their children was obtained for seven students. All of the participating students were labeled as either moderately or severely handicapped in their school records. All subjects were identified by 10/15/83, which was within two weeks of the original project timeline.

Objective 3: Recruit and train project staff

The staff for this project consisted of two trainers to conduct the daily training sessions with the seven subjects. Training consisted of familiarization with the prompting techniques, data collection, reinforcement and general management of subjects during training sessions. All training was conducted by the project director. Training for the two trainers was completed by November of 1983, within the original project timeline.

Objective 4: Assign tasks into treatment conditions

This objective entailed the random assignment of each task in a pair to one of the two treatment conditions. Task assignment was completed in January of 1984. This was within the timeline established in the original proposal.

Objective 5: Implement training and data collection

Training for all seven subjects was initiated in January of 1984 and continued through June of 1984. Training and data collection were implemented within the timeline of the original proposal.

Objective 6: Analyze data on subject performance

Data analysis was initiated in September of 1984. Data analysis was not completed until September of 1985. This was outside of the original project timeline. The reason for delay was a need to write and test several computer programs. These programs were developed to conduct the proposed analyses of data from the study and required significant effort to produce programs that would operate reliably.

Objective 7: Prepare final report

This report constitutes the completion of this objective. The final report is outside of the original project timeline due to the delay in data analysis and the fact that the project director became involved in a position at another university that hindered the completion of the final write-up of the study.

ABSTRACT

Investigation of the Relative Efficacy of Two Response Prompting Techniques as Components of Instructional Packages for Students with Severe Handicaps

Teachers of students with severe handicaps frequently employ various types of assistance antecedent to a student response in order to increase the likelihood that the behavior will be performed. This assistance, which may be auditory, visual, or physical, has been referred to as response priming or prompting. When response prompts are provided they represent an addition to the natural stimulus complex to which the student should eventually respond. Because they are added, response prompts must be faded in a manner that ensures that the behavior will come to be controlled by the naturally occurring stimuli. Several methods have been described to obtain transfer of stimulus control from teacher prompts to natural stimuli. These include: "decreasing assistance"; "increasing assistance"; "time delay"; and "graduated guidance". Systematic comparisons of the effects of those methods are extremely rare. This study investigated the relative efficacy of the "time delay" and "graduated guidance" response prompting methods. The experimental design employed was a variation of the alternating treatments design. Data analysis methods included the use of a randomization test with a correlated t test and repeated measurement data, described in terms of trends. Results of

the randomization tests revealed no significant differences between the performance slopes under the two experimental procedures. Of the 7 subjects, 3 showed no educationally significant progress under either experimental procedure. Acquisition and maintenance slopes for the remaining 4 subjects did not support the superiority of either experimental procedure.

CHAPTER I

Introduction

Statement of the Problem

The result of relatively recent legislative and court ordered mandates for education of students with handicaps has been a proliferation of research directed toward the development and refinement of pedagogical techniques to improve the effectiveness of instruction for this population. The focus of those efforts has been to identify the significant variables associated with: systematic instruction; antecedent events; consequent events; prompting and fading of assistance; and supporting generalization and maintenance of acquired behaviors.

One of the major outcomes of those efforts has been an increasing criticism of the acquisition of isolated skills in instructional environments as an appropriate educational goal for students with severe handicaps (Falvey, Brown, Lyon, Baumgart, & Schroeder, 1980; Wilcox & Bellamy, 1982). It has become a widely recognized fact that acquisition of behaviors in an instructional setting is insufficient to insure movement toward an independent and functional adjustment to one's environment. In order to maximize the functionality of any behavior it must come to be controlled by stimuli naturally occurring in the environment where the behavior will produce an appropriate adaption to that environment. Guess (1980) defined functional in terms of the performance of a skill in the presence of natural cues and maintenance by natural reinforcement. For example, at the end of a training program to teach tooth brushing a student should be able to perform, either fully or partially, the behavior of tooth brushing without the need for reinforcement of the steps within the chain and should also initiate the behavior in the presence of natural cues that indicate it is time to brush teeth. For a child the natural cue might be the parent issuing a directive "brush your teeth." For an adult the natural cue would more likely be the completion of some other morning routine, e.g., showering, drying hair or dressing. If a student has learned to respond correctly only to teacher provided stimuli, there is no reason to assume that response will be displayed in the presence of the naturally occurring stimuli.

Methods of applying and fading reinforcement have been exhaustively investigated and documented in both the experimental and applied research literature. The results of those studies have been disseminated in numerous teacher training programs, texts, and curricula. Unfortunately, the application and fading of reinforcement is insufficient alone to insure the acquisition of functional skills in students with severe handicaps. As Millenson and Leslie (1979) point out, in order for operant conditioning to be effective the behavior in question, or at least an approximation of the behavior, must be occurring at some non-zero operant level. Bandura (1969) also indicates that differential reinforcement alone will only be effective if certain conditions are met, namely, if "responses are composed of readily available elements, stimuli exist that are capable of arousing actions that resemble the desired pattern, erroneous responsiveness does not produce injurious consequences, and the learning agent possesses sufficient endurance" (p. 144).

In the case of students with severe handicaps it is often necessary to provide additional stimuli in the form of teacher assistance. Since these students often do not display any movement resembling the desired behavior, teacher assistance is provided to evoke the response which then results in reinforcement. This stimulus assistance has been referred to as response priming or prompting (Snell & Smith, 1978). Assistance may take the form of verbal directions or questions, gestures or demonstrations of behaviors, or some form of physical contact to guide the student through the response. Since these prompts are "extra," that is, in addition to the naturally occurring stimuli, they, like artificial reinforcement, must ultimately be faded so the student will respond in the presence of the natural stimuli only. For example, if a teacher is providing physical assistance to a student who is learning to sit down in a chair, control of the sitting should eventually be transferred from the physical assistance to the natural verbal cue "sit down" or perhaps the natural visual cue of an empty chair on which the student may sit.

Several methods have been described in the research literature and in training packages to obtain transfer of stimulus control from teacher prompts to natural stimuli. These methods include: "increasing assistance"; "decreasing assistance"; "graduated guidance"; and "time delay". "Increasing assistance," provides a student with assistance based on a hierarchy of prompts from least intensive (verbal) to most intensive (physical) (Close, Irvin, Phrem, & Taylor, 1939; Cuvo, Leaf, & Borokove, 1978; Horver & Keilitz, 1975; and Streifel, Wetherly, & Karlan, 1976). "Decreasing assistance" provides the student initially more intensive prompts (physical) and, after some pre-determined number of correct responses by the student, with a less intensive prompt (model) (Cuvo et al., 1978; Hunter & Bellamy, 1977; Seriebman, 1975; and Zane, Walls, & Thvedt, 1981). "Graduated guidance" emphasizes physical assistance and accomplishes fading through shifts in the locus (point on student's body where contact is made) and intensity of the assistance (Azrin & Armstrong, 1973; Foxx & Azrin, 1971). "Time delay" provides the student with the same prompt (physical, verbal, model) over time, but inserts some pre-determined delay period between the natural stimulus and the teacher delivered prompt (Johnson, 1977; Kliewhert & Gast, 1982; Snell, 1982; Stremel-Campbell, Cantrelle & Halle, 1977; and Streifel, et al., 1976). Each of those four methods has been employed successfully to teach skills to students with severe handicaps and to transfer stimulus control to natural stimuli.

Comparative Studies

Given the extent to which the above four methods have been demonstrated to be individually effective and have been adopted by teachers it is surprising to note that systematic comparisons across methods are extremely rare. The lack of evidence in regard to the relative efficacy of prompting methods leaves teachers without any guidelines for selecting methods to use. Quite often it would seem that teachers select a prompting method based upon either their familiarity with that method or the fact that it is the method that is recommended for use with the curriculum they have adopted for their class. Empirical verification of the relative efficiency of prompting methods could result in a rational basis for prompt method selection. This would result in more rapid skill acquisition for students with severe handicaps and improved performance in the presence of natural stimuli.

Only five comparative studies of response prompting methods were identified in the literature. Those studies have compared the "increasing assistance" method with "decreasing assistance" (Caspo, 1981 and Gentry, Day & Nakao, 1980), and "time delay" with "increasing assistance" (Renzaglia & Snell, 1981; Bennet, Gast, Wolery, & Schuster, 1986; & Goodby, Gast, & Wolery, in press).

The results of those five comparitive studies indicate that the decreasing assistance method was more effective than the increasing assistance method in the acquisition phase of learning, but the results were reversed in the fluency building phase. The findings related to the increasing assistance versus the time delay method indicate that the time delay procedure is at least equal, and possibly superior to, the increasing assistance method. To date there has been no investigation of the coparative effectiveness of the graduated guidance method.

The Research

This research study compared the relative effectiveness of the graduated guidance and time delay methods when those methods were included as components of instruction interventions. Graduated guidance and time delay were chosen for comparison in order to extend the knowledge of the relative effectiveness of those prompting methods. The results from this comparison will hold to information recording the effectiveness of prompting methods and aid practitioners in selecting more efficient instructonal interventions. The graduated guidance method has been used to teach behaviors such as eating and toileting (Azrin & Armstrong, 1973; Foxx & Azrin, 1973) and to decelerate the occurrence of undesirable behaviors (Foxx & Azrin, 1972). It has also been frequently recommended for use with persons with severe handicaps (Popovich, 1981; Snell, 1978: De Vore, 1977). Likewise the time delay method has been widely employed to teach a variety of behaviors to students with severe handicaps. Among those behaviors are: visual discriminations (Johnson, 1977; Touchette, 1971), instruction following (Streifel Bryan & Aikins, 1974; Streifel, et al., 1976), spontaneous requests (Halle, Marshall, & Spradlin, 1979), manual signing (Kleinert & Gast, 1982; Stemel-Campbell, Canstralle & Halle, 1977), and bed making (Snell, 1982).

This study addressed a problem encountered by virtually every teacher of the severely handicapped, i.e. what response prompting methods are most effective when embedded in instructional intervention programs. Because response prompting techniques are frequently employed in classrooms for the students with severe handicaps, the identification of methods which have the highest probability for success could have a widespread impact on the behavior of teachers and the learning of their students. The empirical demonstration of the relative effectiveness of response prompting techniques could reduce instructional time, decrease the need for student dependence on teacher assistance, and ultimately lead to an increase in the functionality of skills learned by students.

Hypotheses

In order to evaluate the competitive effectiveness of the graduated guidance and time delay methods of response prompting the following hypotheses were tested in this study:

1. There is no significant difference in the line of progress slopes between the time delay and graduated guidance instructional intervention programs.

2. There is no significant difference in instructional time to aim between the time delay and graduated guidance instructional intervention programs.

3. There is no significant difference in trials to aim between the time delay and graduated guidance instructional intervention programs.

CHAPTER II

Review of the Literature

Teachers of the severely handicapped must often deal with what Skinner (1968) describes as the problem of the first instance of behavior. This problem points to the need for a behavior to occur at some non-zero operant level (Millenson & Lesile, 1979) in order to provide the opportunity to reinforce that behavior. Since severely handicapped students often display relatively low rates of movement, teachers must frequently provide some form of assistance antecedent to the student's response to increase the opportunity to provide reinforcement of the behavior. This assistance may be auditory (verbal cues, bells, etc.), visual (signs, words, demostrations, models, etc.), or physical (full or partial manual guidance) and is labeled as response priming or prompting (Snell, 1978).

Four distinct methods of response prompting have been identified in the literature. These methods are often refered to as: decreasing assistance; increasing assistance; graduated guidance; and time delay. Each of these methods has been demonstrated to be effective in teaching a variety of behaviors to severely handicapped individuals. A brief description of each method is provided below.

Decreasing Assistance

This method initially provides the student with a prompt which will insure a correct response. This level of prompt is later faded by shifting to a lessser level of assistance once a predetermined number of correct responses are achieved. The procedure of shifting to lesser levels of assistance continues until the student is responding in the presence of the natural stimulus only. If a student fails to respond correctly at some lesser level of assistance, the training may be moved back to the next higher level of assistance. The levels of assistance most commonly employed, in decreasing order, are: full physical assistance; partial physical assistance; gestures; demonstrations; directive verbal assistance (i.e., get your coat, pick it up); and non-directive verbal assistance (i.e., what comes next? try another way) (Cuvo et al., 1978: Hunter & Bellamy, 1977; Schreibman, 1975; and Zane et al., 1981). The hierarchy is not always as detailed as the one described above. Certain levels are sometimes omitted, such as non-directive verbal (Cuvo, et al, 1978) or demonstration and non-directive verbal assistance (Csapo, 1981).

Increasing Assistance

The intent of this method is to provide the student with the least level of assistance required to evoke a correct response. The hierarchy of levels of assistance is exactly reversed from that of the decreasing assistance method. The initial assistance level follows the occurrence of the natural stimulus conditions. The first level of assistance is a verbal prompt. If the student fails to respond within a predetermined latency, or the response is incorrect, the teacher then provides the next higher level of assistance. This procedure continues until a correct response is evoked. This method is sometimes refered to as "self fading" because the student is always given the opportunity to respond to the natural stimulus prior to the delivery of any assistance by the teacher. It is expected that at some point the student will respond correctly before any assistance is provided by the teacher, thus accomplishing the transfer of stimulus control. As is the case with the decreasing assistance method, the increasing assistance method sometimes omits certain "shadings" of the levels of assistance, e.g., non-directive verbal or partial physical assist. However, the progression of assistance is always from the least to the most intrusive level (Close, Irvin, Phrem, & Taylor, 1979; Cuvo et al, 1978; Horner & Keilitz, 1975; Striefel et al., 1976).

Graduated Guidance

This method is primarily physical assistance provided by the teacher at whatever level is necessary to insure a correct response from the student. The unique characteristics of this method are that it emphasizes the physical level of prompt and that it accomplishes fading through a shift in the locus and/or intensity of the assisstance provided. For instance, the teacher may first provide assistance to the student by placing her hand directly on the student's hand and completely guiding the correct response. Subsequently the teacher's hand would only "shadow" the student's hand through the response, or the physical guidance could be replaced by the teacher lightly touching the student's wrist, then elbow, and finally the shoulder to prompt the response. This fading of locus and/or intensity of the teacher assistance continues until the student is responding to the natural stimulus only (Azrin & Armstrong, 1973; Foxx & Azrin, 1971).

Time Delay

This method of prompting involves the manipulation of the temporal relationship between the naturally occuring stimulus and the prompt. The time delay procedure was originally operationalized by Touchette (1971) and recently reviewed by Snell & Gast (1981). Two major variations of this method are identifiable in the literature, constant and progressive time delay. In both procedures the relationship that is manipulated is the interval between the natural stimulus and the teacher delivered prompt. The progressive time delay method gradually increases the latency between the natural stimulus and the prompt. For example, the first delay level might be 1 second between the natural stimulus and the prompt; after each succesful trial this delay level is then increased by 1 second. The constant time delay procedure utilizes only one level of delay. Usually in this variation the initial trials present the prompt concurrently with the occurance of the natural stimulus. Following this block of concurrent trials subsequent trials are presented with a fixed latency inserted between the natural stimulus and the prompt (Kleinhart & Gast, 1982). This fixed level of delay remains the same throughout training. Both methods affect transfer of stimulus control when the student responds prior to the prompt and in the presence of the natural stimulus only (Johnson, 1977; Kleinhert & Gast, 1982; Snell, 1982; Stremel-Campbell et al., 1977; Streifel et al., 1974).

Comparative Studies

All of the above prompting methods have been demonstrated to be effective in skill instruction of severely handicapped students. However, few studies have been undertaken to investigate the relative effectiveness of those four prompting methods. Only five studies have investigated across method effectiveness and one study investigated the effectiveness of within method variations.

Gentry et al. (1980) compared the increasing assistance method with the decreasing assistance method of prompting. This study employed 4 severely retarded subjects ranging in age from 15 to 21 years old. The task trained was a two choice visual discrimination. A combination multiple baseline/crossover design was utilized. Probes were conducted at the end of each training session on the rate of correct and error responses. The major findings of this study indicate that the decreasing assistance method resulted in an acceleration of correct rates and a deceleration of error rates, while the increasing assistance method resulted in accelerating error rates and decelerating correct rates. None of the subjects acquired the discrimination under the increasing assistance method while all succeeded in acquiring the discrimination under the decreasing assistance method. The authors state that the superiority of the decreasing assistance method, while seemingly clear, must be considered with regard to certain limitations. These limitations include: the nature of the task trained, i.e. simple visual discrimination as opposed to motor chaining; the phase of learning, i.e. initial acquisistion versus fluency building, maintainence, generalization, or adaptation; and lastly, the type of subjects, i.e. compliant, easily trained individuals rather than non-complaint students for whom effective reinforcers are difficult to identify.

Csapo (1981) replicated the Gentry et al. study, but investigated the effects of the increasing and decreasing assistance methods during the fluency building phase of learning as opposed to the acquisition phase. The task was a two choice visual discrimination and the experimental design was a combination multiple baseline/crossover. Six subjects ranging in age from 12 to 16 served in the study. Their Vineland Social Maturity Scores ranged from 20 to 41, and all were non-verbal and engaged in self-stimulating behaviors. The major findings reported were: decreasing assistance resulted in a steady gain in correct rates and consistantly low error rates; the increasing assistance method resulted in an initial drop in correct rates and a rise in error rates, however, after reestablishing the previous correct rate, correct responses began to increase at a higher rate than under the decreasing assistance method. Csapo concluded that in the fluency building phase of learning the increasing assistance method of prompting was more efficient than the decreasing method, once a high rate of correct responses and a low rate of errors had been established. Billingsley and Romer (1983) noted that the conclusions drawn by Csapo must be considered with regard to other evidence of strategies demonstrated to be effective in increasing rates during the fluency building phase of learning. Haring, Liberty, & White (1980) reported that, during the fluency building phase of learning, drill, practice, and consequence manipulation seem to be most effective in increasing rates, while during acquisition it is information, (e.g., prompts) that seem to be the most efficient intervention strategy. Based on the evidence provided by the Csapo study, one might question whether the investigation of response prompting during the fluency building phase would provide useful information for teachers. It is during the acquisition phase of learning when response prompts would be expected to facilitate the rate of skill acquisition.

Three studies investigated the relative effectiveness of the time delay method of prompts and the increasing assistance method. Renzaglia & Snell (1981) compared those two methods in training manual sign acquisistion. Seven of eight subjects in this study were severely retarded, and one was moderately retarded. Ages of the subjects ranged from 13 to 19 years. IQ's ranged from 20 to 49. All subjects were instructed in manual sign acquisistion through the use of a board game. Each subject was to receive instruction on 12 signs, 6 in each of two games. The design employed was a multiple baseline/crossover. The crossover involved the method of instruction used for the two game conditions, i.e., four subjects received training under the time delay method in game 1 and under the increasing assistance method in game 2, while the remaining four subjects received their training in the opposite order. Dependent measures were the percentage of errors committed by subjects under each condition and the number of trials to criterion. Of the eight subjects, two made no observable gains. Of the six subjects who made gains, four acquired all signs trained under both conditions. Statistical analysis (Wilcoxen Matched Pairs) revealed no significant differences between the two methods in terms of error rates. Visual inspection of the data showed no meaningful difference between the two methods on trials to criterion. The authors concluded that both methods were effective in training manual sign acquisistion to severely retarded subjects.

A second study (Bennett et al., 1986) also compared the effectiveness of time delay and increasing assistance upon the acquisistion of manual signs. Ages of the three subjects ranged from 14 to 17 years, and their Vineland Social Maturity scores ranged from 4.8 years to 6.9 years. One subject had no functional signs, while the remaining two had functional sign vocabularies of approximately 60 signs. All signs trained in the study were novel to the subjects. A parallel treatments design was employed in this study. This design is essentially two simultaneously implemented multiple probe designs. Each subject received training on 8 signs. Those eight signs formed four pairs, with each member of each pair being trained under a different condition. The order of training was counterbalanced on a daily basis. All subjects learned all signs presented for training regardless of the prompt method employed. However, less trials to criterion, sessions to criterion, errors to criterion, and minutes of instructional time were required under the time delay method of prompting. The authors concluded that the time delay technique was more efficient than the increasing assistance method in training manual signs to severely retarded subjects.

In a study similar to that by Bennet et al., Goodby et al. (in press) empoyed the same design and dependent measures to evaluate the time delay and increasing assistance prompt methods on the acquisistion of object identification responses. The three subjects in this study were all severely retarded, with an age range of 9 to 17, and TARC Assessment System scores ranging from 51 to 70. The results obtained were essentially the same as those in the Bennet et al. study. All subjects acquired all of the object identification responses regardless of the prompt method employed. However, as in the Bennet et al. study, less sessions, trials to criterion, errors, and minutes of instructional time were reported under the time delay condition.

Only one study (Zane, Haught, & Dowler, 1982) was identified in the literature that investigated the effectiveness of within prompt method variations. Zane et al. (1982) investigated the relative effectiveness of different prompt delay levels in the progressive time delay method of prompting. Delays that increased by 1 second, 3 seconds, or 5 seconds were investigated. Twenty subjects served in this study, with ages ranging from 17 to 60, and IQ's ranging from 32 to 67. The median IQ was used to divide the subjects into high and low aptitude groups. The subjects were trained to assemble three different apparatuses using three different delay levels. The order of training on the apparatuses and the order of the delay levels were randomly assigned across subjects. Dependent measures were: number of errors; last trial on which an error was made; number of trials with no errors; and total training time. The design employed was a 2 x 3 mixed design, with one across-subjects variable (high versus low aptitude), and one within-subjects variable (prompt delay level). Data were analyized through a 2 x 3 mixed analysis of variance. Results indicated a significant main effect for delay conditions on all variables. The Duncan Multiple Range Test revealed the fewest errors, most trials with no errors, and earliest acquisition occured under the 1 second progressive delay level. These authors discuss the effectiveness of various delays between the presentation of the natural stimulus and the trainer prompt. They concluded that longer delay levels, such as 15 seconds or 25 seconds, which occured in the 5 second progressive delay condition, were ineffective in that few subjects waited for 15 seconds and none waited for 25 seconds before responding. They stated, "...3 seconds (Trial 4) and 5 seconds (Trial 6) were reasonable delays that the learners could use effectively. If they were sure of the correct response, the time was ample to initiate it; if they were unsure of the response, a delay of 3 or 5 seconds was not an unusual or punishing period to waitn for help" (p. 315).

The results of the five across method comparisons are summarized in Table 1.

Insert Table 1 about here

As noted by Billingsley & Romer (1983) the results of comparative studies undertaken to date seem to indicate that the decreasing assistance method of prompting is more effective than the increasing assistance method with severely handicapped learners in the acquisistion phase of learning, and that the time delay method is at least as effective as the increasing assistance method, and perhaps even more effective in some conditions. Zane et al. (1983) provide the only empirical evidence regarding the most effective delay levels to employ in the time delay system of prompts. The graduated guidance method of prompting has not been investigated in comparison to other prompting techniques, and decreasing assistance has been compared to neither the time delay nor the graduated guidance technique. The literature on the comparative effectiveness of prompting methods currently presents practitioners with an incomplete mosaic to guide their choices of prompting techniques.

Theoretical Framework

Until recently the only theoretical framework utilized to classify prompting techniques was based on whether the techniques were considered examples of errorless learning or not. Errorless learning has been described by several authors including; Terrace (1963), Sidman and Stoddard (1967), and Touchette (1968). The basis of the errorless learning model is the exageration of the relevant stimuli in order to increase the probability of a correct response occuring. Errorless learning begins with a large difference between the relevant and irrelevant discriminative stimuli. Once correct responding is established the large differences between relevant and irrelevant stimuli are faded until the subject is responding to the relevant stimulus only.

In the case of severely handicapped students, who often do not move or are exceedingly slow in their movements, the exageration of relevant stimulus features will often not be an effective method for eliciting responses which can then be reinforced. Gentry et al. (1980) describe the decreasing assistance technique's use of extra dimensional stimuli, in the form of trainer assistance, as an alternative to the exageration of relevant stimulus features. The critical aspect of prompting techniques that define them as errorless learning models is whether or not they are likely to result in the occurance of a correct response in conjunction with, or in close proximity to the natural stimulus. In addition to decreasing assistance, graduated guidance and, at least potentially, time delay would also appear to result in this outcome. The proximity of the natural cue to a correct response in the time delay methods is affected by the delay level employed. The increasing assistance technique does not seem to have any base in the experimental literature nor would it seem to result in a high occurance of correct responses in the presence of the natural stimulus.

Recently Billingsley and Romer (1983) proposed an alternative framework to guide research on the relative efficacy of prompting methods. The basic premise of this framework is that prompts should be examined in relation to the variations that occur as the prompt is faded and focus on how the learner receives the prompts rather than on how the teacher delivers them. Figure 1 represents the relationship of each prompting technique to at least some of the major factors that could influence the transfer of stimulus control.

Insert Figure 1 About Here

The factors that potentially affect the transfer of stimulus control in the graduated guidance method are both the variation within/across sensory modalities and the variation in iconicity. Variation within modalities refers to the gradual lessening of physical assistance provided to the learner in this method. There are actually two modalities involved in graduated guidance, the tactile/kinesthetic aspects of the physical assistance and the visual stimuli associated with the trainer assisting the learner to move through the response. Variation across-modalities in the graduated guidance method is minimal in comparison to the increasing and decreasing assistance methods. The only across modality shift occurs in the movement from partial physical assistance to shadowing, which is essentially dropping the tactile/kinesthetic mode and going to only visual stimuli.

In contrast to stimulated guidance, the increasing and decreasing assistance methods shift across the tactile/kinesthectic, visual and auditory modalities. Additionally, those methods often pair auditory cues, in the form of teacher vocalizations, with the other levels of assistance. The learner may, therefore, receive input through three modialites simultaneously. In any case, the graduated guidance method utilizes only the tactile/kinesthetic and visual modalities and never shifts to a different modality, accomplishing fading within these same modalities. Terrace (1963) has demonstrated that abruptly shifting from one stimulus dimension to another results in an increase in error responding. Since the graduated guidance method promotes transfer by movement through the physical and visual modalities, with no shifts to other modalities, it may prove to be a more efficient method for obtaining transfer to the natural stimulus.

Variations in iconicity refer to whether the prompt is illustrative or symbolic. An illustrative prompt is one that provides a "picture" of the response to the learner and is therefore highly iconic. A symbolic prompt on the other hand imparts information to the learner through some "code". This code may have very little or no iconicity. It is at least arguable that illustrative prompts provide more information to the learner than symbolic ones. If this is true then prompt hierarchies that fade assistance without shifts from illustrative to symbolic prompts may be more effective than ones which do. Once again, graduated guidance seems to be the one prompt hierarchy which does not shift in terms of iconicity. This method provides the learner with illustrative prompts throughout the fading process.

In contrast to the graduated guidance method, the time delay method affects the transfer of stimulus control variation in the temporal relationship of the natural stimulus to the prompt. Since the prompt in the time delay method never changes (i.e. is always a model, gesture, physical assist, or auditory cue) there is no variation in either the modality or the iconicity. The prompt is either present in full force or, once the learner begins to anticipate the prompt, it is totally absent.

A comparison of the graduated guidance and time delay methods may be described as a comparison of the effect of fading an extra dimensional stimulus through the manipulation of the physical/visual modality as opposed to fading through the manipulation of the temporal relationship of the natural stimulus and the prompt. Data obtained through this study, then, may not only provide evidence as to the relative efficacy of the graduated guidance and time delay prompt methods, but also may provide information useful in further development of a conceptual framework of prompt fading and its effect on transfer of stimulus control. It would then be necessary to evaluate the treatment effects of the two response prompt methods in isolation from other components of instructional intervention programs, i.e. reinforcement density.

CHAPTER III

Method

This study employed a replicated single subject, repeated measures design. Seven subjects served, thereby yielding one experiment with six direct replications across subjects. For the purposes of this study it was determined that a single subject design would offer certain advantages. First, because of the extreme heterogeneity of the severely handicapped population, group designs which average results of treatments across subjects would tend to obscure any individual results (Edgar & Billingsley, 1974; Hersen & Barlow, 1976). In single subject designs, performance during treatment is compared with performance during baseline, and/or performance during other treatment conditions. In such cases each subject serves as his/her own control. Second, employing a single subject design permits detailed analysis of the process of behavior change rather than reliance only on the product measures employed in group designs (Hersen & Barlow, 1976; Kratochwill, 1978). Third, since the focus of special education is on the development of individualized interventions, not group interventions, single subject designs are more effective in yielding results indicative of how individuals learn as opposed to learning that occurs in groups.

Although many frequently cited repeated measurement, single case designs (e.g., multiple baseline and withdrawal) have been developed to compare performance under treatment conditions to baseline, other designs have been developed to permit comparison of two or more treatments in the same subject. One of these designs, the alternating treatments design (Barlow & Hayes, 1979), requires the rapid alternation of two or more treatments in random or counterbalanced order. Although this design has been used most frequently to examine the effects of two or more treatments on a single behavior, its use could be extended to study multiple behaviors. Multiple behaviors were needed in this study to examine the differential effects of two treatments upon the acquisition of new skills in the subjects. This application required that the behaviors be similar in terms of baseline levels of performance, be trained with different treatment procedures, and that the treatments assigned to each behavior be varied across subjects.

The alternating treatments design, with random order of treatments in blocks of two, can be diagrammed as follows:

	Baseline				Treatments						
Subject	b	a	b	. . . .	a^1	a^1	b^2	a^1	b^2	b^2	. .
. . X	a	b	a		b^2	b^2	a^1	b^2	a^1	a^1	
Subject	a	b	a	. . . .	b^1	b^1	a^2	b^1	a^2	a^2	. .
. . Y	b	a	b		a^2	a^2	b^1	a^2	b^1	b^1	

Where: a & b are behaviors
1 & 2 are treatments

The alternating treatments design, with slight modification, was employed in this study. Two behaviors were trained per day. One behavior in the pair was trained using graduated guidance, the other with time delay. Each session was approximately 10 minutes in duration. Training for 2 minutes alternated with 30 second performance probes. There was no break between training on the two behaviors. The behavior trained first was randomly determined by coin flip each day.

Subjects and Settings

The seven subjects for this study were drawn from classrooms at Sorenson School, Northshore School District and Gordon Hauck Center, Lake Washington School District. Four subjects were drawn from Sorenson School, the other three from Gordon Hauck Center. These seven subjects were the only students who met the following criterion, and for whom parental consent to participate was obtained:

1 - Subjects had to pass four items from the Uniform Performance Assessment System (White, Edgar, Haring, Affleck & Hayden, 1978). These items were administered to evaluate the subject's ability to perform the tool movements required for the training tasks. These items were:

PA-4 - reaches for object
PA-5 - grasps object
PA-6 - grasps object in each hand simultaneously
PA-7 - picks up object with pincer grasp.

2 - All subjects had to meet the following State of Washington (WAC 392-171-42) criterion for measured level of functioning to be classified severely/profoundly mentally retarded:

"Intellectual functioning (IQ) range under 30 and the following:

(i) Academic functioning equal to one-third or less of chronological age/grade and

(ii) Adaptive behavior equal to one-third or less of chronological age/grade"

Following is a description of the seven subjects:

Subject 1 - Subject #1 was male and 21 years old as of 1/1/84, the beginning of this study. He was classified as severely retarded by an assessment conducted two years prior to this study with no specification of the instrument(s) administered. He displayed a moderate to severe hearing loss and spastic quadripalegia. He possessed most self-care skills, such as toileting, eating and dressing. His communication was through approximately 50-75 signs and a communication book he carried attached to his belt. Programs this subject received training on in class consisted of prevocational tasks such as sorting, packaging, etc., and some cooking and other domestic skills.

Subject 2 - Subject #2 was female and 13 years 8 months old at the beginning of this study. She was classified severely retarded with diagnosis of Sturge-Weber syndrome. Quadric paresis resulted from status epilepticus four years prior to this study. Bayley Infant Scales showed a MA of 7 months at 22 months of age. This subject possessed no self-care skills. Although she could walk, her gait was very unsteady and slow. She was more often moved by staff in her wheelchair. S2 was non-verbal with no other communication system. She tended to engage in self-stimulating behavior consisting of tapping objects on tables, her wheelchair, etc., whenever she was given objects to manipulate.

Subject 3 - Subject #3 was male and 13 years 9 months old at the beginning of this study. The Lieter International Performance Scale yielded an IQ of 31. No basal score was obtainable on the Peabody Picture Vocabulary administered four years prior to this study. This subject was non-verbal and displayed severe arthrogryposis of the lower extermities. He communicated primarily through a communication book attached to his belt. S3 did follow commands displaying a high level of receptive language skills. He possessed all self-care skills.

Subject 4 - Subject #4 was male and 14 years 2 months old at the start of this study. He was classified as severely retarded with a Vineland IQ of 25. S4 was totally blind. He had no functional speech and engaged in common blind behaviors, i.e. head rocking and body weaving. S4 possessed some self-care skills such as toileting, but did not dress himself nor was he able to attend to his personal hygiene needs. S4 did respond to most simple commands, but only communicated expressively through grunts and squeals.

Subject 5 - Subject #5 was female and 18 years old at the start of this study. She was classified as severely/profoundly retarded with a WAIS IQ of 30 obtained one year before this study. S5 was highly verbal displaying both good expressive and receptive language skills. She possessed all self-care skills and was independent in several recreational/leisure activities. She displayed several inappropriate behaviors such as disrupting the activities of others, using profane or hostile language, threatening or actually engaging in physical violence, property damage, stealing and disrobing.

Subject 6 - Subject #6 was male and 19 years 4 months at the beginning of this study. No standardized testing was completed with this subject due to his low functioning and non-cooperative behavior. S6 had no communication skills at all, other than resisting when he did not want to engage in an activity. He was non-responsive to communication from others. He did not feed or dress himself. He was partially toilet trained. S6 engaged in frequent self-stimulating behaviors such as rocking, twirling and stereotypic hand movements.

Subject 7 - Subject #7 was male and 19 years 4 months old at the start of this study. No standardized assessments were completed due to this subject's low functional level. He was classified as severely retarded with a diagnosis of static encephalopoly, static quadriperisis, and mixed seizure disorder. S7 possessed no self-care skills, but was partially toilet trained. He had no expressive language skills and only slight responsiveness to verbal commands.

Subjects 1-4 attended Sorenson School which is a segregated, self-contained school for students with disabilities ragning from mild to severe. Students in this school ranged from pre-school age to 21. They received all their training in a room separate from their regular classroom. No one was present in this room, other than the trainer and subject, while training was being conducted except on days reliability was assessed. Subjects 5-7 attended Gordon Hauck Center, also a segregated, self-contained school serving students with mild to severe disabilities from preschool age through 21. They received training in an area adjacent to their regular classroom. The classroom was quite large and was used primarily for prevocational training. Training for this study was conducted at a table adjacent to the area used for breaks by the other students, but only when no other students were on breaks. Both schools were located in different school districts and were therefore under separate administrative units.

Trainers

The trainer for subjects 1-4 had no experience in training students with severe handicaps. Her prior experience in the field of special education consisted of serving as a research assistant on a project studying the language development of infants. The trainer for subjects 5-7 was a college sophomore majoring in psychology. She was formerly employed as a peer tutor for students who were deaf and blind on a federal contract at the University of Washington.

Both trainers received approximately 40 hours of preservice training from the author prior to working with any of the subjects. This training consisted of how to employ the prompting techniques under investigation, data recording, consequation of behaviors, gaining subject's attention and providing cues. Training exercises included reading materials describing the prompt methods employed in the study and practice sessions during which the trainers employed the prompt methods with each other on the tasks included in the study.

The author initially modeled the use of the prompt techniques, delivery of consequences and data recording and later observed the performance of the trainers in teaching each other the tasks. Feedback was provided and reliability data collected during training sessions. Training was terminated when trainers performance reached 90% reliability.

Trainers utilized plan sheets prepared for the presentation of task materials to subjects during their training sessions and during training sessions with subjects. The plan sheets included what cues to provide subjects, the layout of materials, what were to be recorded as correct and error responses and the consequation to be delivered for correct and error responses.

Task Selection and Randomization

The Trainee Performance Sample (TPS) (Irvin, Gursten, Bellamy, Taylor, & Close, 1980) served as the source of tasks for subject training. Raw data from the validation studies of the TPS were used to analyze the tasks for the purpose of selecting those that were functionally most equivalent, i.e., of approximately equal difficulty. These validity data were obtained from a sample of 149 moderately, severely, and profoundly retarded subjects who were receiving services from community adult vocational programs or a large state institution in the Northwest. The TPS contains 25 items that are presented to subjects by either verbal cue, model, or physical prompt.

Trainer Performance Sample Data Analysis

The identification of functionally equivalent tasks was accomplished through an examination of the data from the validity study of the TPS. These data represent the performance of 149 subjects on the 25 tasks that comprise the TPS. The performance of subjects was compared on all possible pairs of the 25 items. The 25 items were first arranged in a hierarchy of ascending difficulty. This hierarchy was based on the mean score for each item obtained from the performance of the 149 subjects. Possible scores were 0 (incorrect on two trials), 1 (correct on one of two trials) or 2 (correct on 2 trials). Next, each subject's scores or items appearing later in the hierarchy were subtracted from his scores on the item they were compared with. For example, the item appearing first in the hierarchy was compared to the next 24 items by subtracting all the subsequent scores of item 2 from their scores on item 1, item 3 from item 1, etc. Once this set of subtractions was completed, item 2 was compared with the next 23 items by the same subtraction method. The result of subtracting the item scores was data in the form of a distribution, such as in the example provided below, for all the possible pairs:

+	0	-
25	100	24

The data under zero indicate that 100 subjects received the same score on both items, that is, they either passed both, failed both, or performed correctly on 1 out of two trials on both items. The data under "+" indicate that 25 subjects' scores on item 1 were higher than those same subjects' scores on item 2, that is, item 2 was more difficult than item 1. The data under "-" indicate that for 24 subjects item 1 was more difficult than item 2.

The most desirable data pattern for demonstrating equivalent difficulty would be one with a high number of zeros (indicating equal performance on both tasks) and similar (close to equal) counts in the positive and negative columns. The similarity in positive and negative counts would indicate that at least some subjects performed differently on the two tasks. If there were no counts in the positive or negative columns the tasks might be so similar as to be effectively the same. In that case, learning on one task could easily transfer to the other task in the pair, thus masking any differential treatment effects.

These data alone were insufficient evidence to state that any two tasks were equally hard or equally difficult to learn. A pair of items failed by 50% of the subjects could have been adding single digit numbers and solving differential equations. The fact that both of these items were failed (or passed) by 50% of the subjects does not provide any information on how difficult the two items were to learn in comparison to each other.

Independent Rater Rankings

Fortunately items as disparate as simple math facts and differential equations are not included in the TPS. Most TPS items involve simple manipulations of common objects. These manipulations generally consist of either pick up and place, or pick up, place and manipulate. In any case, all pairs that were formed on the basis of analyses of the validity data from the TPS were subjected to a critical evaluation of their similarity in terms of the manipulations involved in performing the tasks.

This evaluation was accomplished through independent ratings of task similarity by a panel of persons experienced in the education of individuals with severe and profound handicaps. Those ratings were used to complement the analysis of the 149 subject responses from the TPS validity study. The TPS validity data grouped items by pairs based on the performance of 149 subjects, while the panel ratings were used to supplement those pairings through their opinion as to the equivalency of items in the pairs. These raters were classroom teachers and university educators who dealt on a consistent basis with the education of persons with severe and profound handicaps.

Each rater was sent a set of cards describing the TPS items. One side of the card provided a verbal statement of the materials and behavioral objective. The reverse side provided a picture of the materials and diagramed the manipulation to be performed. Raters were asked to place the cards in what they considered to be an ascending order of difficulty.

The raters rankings of item in pairs that were judged to be approximately equivalent based on the TPS validity data were subjected to dependent _t_ tests. A significant _t_ result was taken as an indication that one item in the pair was ranked higher in difficulty by the raters. Conversely, a non-significant _t_ test result was taken as an indication of a tendency to rate one item higher in difficulty and therefore supporting the argument of equivalent difficulty arrived at through analysis of the TPS data.

Experimental Subjects Pretest

All subjects were probed on their performance of each task prior to the initiation of training. Probes consisted of a 1-minute timing of the subject's rate of correct and error performance. Two probes were conducted on separate days. Correct responses were any movements on the part of the subject that achieved the critical effect of task completion. For example, if the task were to place a screw cap on a bottle tightly enough so it would not fall off, then any movement (i.e. pincer grasp, palmar grasp, picking the bottle up first or picking up the cap first etc.) would be an acceptable response as long as it achieved the critical effect of the cap's being on the bottle tightly enough so as to not fall off.

The aim rate for correct responses per minute varied from task to task. Those rates were established by gathering data on the performance of non-handicapped individuals on each of the tasks included in the study. Aim rates were established at 25% of the mean rate attained by non-handicapped peers for each task. The tasks selected from the TPS are all considered to be components of vocational skills commonly found in subsidized employment programs and these programs generally use a 25% productivity rate as a standard for the admission of workers.

Task pairs were formed on the basis of the analysis of TPS validity data and panel rankings. Each subject was pretested on the tasks in each pair of items judged to functionally equivalent. If a subject performed above aim on a task another pair was formed. This resulted in different pairs of items for some subjects and some pairs where the TPS validity data and/or panel rankings did not support as strong a conclusion of item equivalency.

Within pairs, each task was randomly assigned, by coin flip, to one of the two treatment conditions. Once the tasks in each pair were assigned to treatments, all task pairs were randomly assigned to an overall order of training sequence for each subject (i.e. pairs 1, 3, 5, 6, 4, 2, etc. within each subject). On each day of training, a coin flip determined which task was trained first.

Training and Assessment Procedures

Training occurred in daily 10-minute sessions for each task in a pair. Sessions began with 2 minutes of training followed by a 30 second assessment probe. There were four blocks of 2 minutes train/30 second probe per session. Training for each task pair was limited to 5 sessions, thus yielding 20 probes per task.

To initiate the assessment probe the trainer provided a verbal cue to the student to start the task. Immediately after providing the verbal cue the trainer started a stop watch. If the subject made no movement to perform the task the watch continued to run until 30 seconds had elapsed and a rate of zero correct was recorded. If the subject began to respond, and the response resulted in either an error (i.e., did not achieve the critical effect) or a correct response, the watch was stopped, the response was recorded as either correct or error and the task cue was presented again. This procedure continued until a cumulative time of 30 seconds was recorded on the watch.

The 8-minutes of training in the daily sessions was conducted on a trial by trial basis. Each trial began with the trainer providing a verbal cue to perform the task. After the verbal cue the trainer provided prompting in accordance with either the time delay or graduated guidance methods.

Reinforcers were selected for each subject by requesting that their teachers provide a list of items found to function as reinforcers in past programs. The delivery of reinforcement was in accordance with the recommendations stated in the literature for each of the two prompt methods. In the graduated guidance method reinforcement is delivered both during and at the end of each trial (Foxx & Azrin, 1973). The reinforcement delivered during the trial is in the form of social praise. The reinforcement at the end of the trial may be additional social praise or edibles, tokens, etc. This study provided end of trial reinforcement on a CRF schedule. No specific schedule is recommended in the literature for the delivery of intra-chain reinforcement. Trainers in this study were directed to deliver social praise to the subjects once or twice during each trial contingent on subject cooperation with trainer assistance, or independent performance.

In the time delay method of response prompting reinforcement is provided for either anticipated or wait responses. An anticipated correct response is one in which the learner responds correctly prior to the delivery of the prompt. A wait correct response is one in which the learner waits for the prompt to be delivered and is then guided through the response by the trainer. Reinforcement is then delivered to the learner on a CRF schedule for either wait or anticipation corrects. Unlike the graduated guidance method, no reinforcement is provided to the learner during delivery of the prompt. If the learner anticipates the prompt, but performs incorrectly, the trainer interrupts the response, assists the learner to complete the response correctly, and provides no reinforcement at the end of the trial.

The delivery of reinforcement in accordance with the recommendations for the two prompt methods might result in a difference in the density of reinforcement under the two methods. This possible difference in density per unit of time could be a result of more trials being completed under the graduated guidance method. Since any difference in effects found between the two treatments in this study could be attributed to the difference in reinforcement density, during reliability checks data were collected on the number of reinforcers delivered. This entailed a count being made of all reinforcers delivered during reliability checks. The reinforcer count was transformed into a rate of reinforcement per minute under the two prompt methods. Those data allowed for an evaluation of the difference in reinforcement density under the two prompt methods.

Since this study attempted to teach six tasks to each subject over a period of 9 weeks the potential for the subjects to become satiated on any one reinforcer had to be considered. In order to minimize that possibility, 2-3 potential reinforcers were identified for each subject. Those reinforcers were available for use with the subjects for any given session. Prior to each training session, the trainer randomly selected one of the reinforcers for use throughout that training session.

Since the training prompt employed in the time delay method is a physical assist and the graduated guidance method is itself physical assistance, the possibility for error responses occuring were minimal. The only possibility for errors was if the subject refused to accept assistance from the trainer (non-compliance) or the subject anticipated the prompt under the time delay condition, but performed incorrectly. The anticipated error was interrupted by the trainer, corrected through physical assistance, and no reinforcer was delivered at the end of the trial. Non-compliance errors can occur under either of the prompt methods. If a subject refused to allow the trainer to assist, a short time out period (10 seconds) was utilized prior to instituting the next trial. This strategy was only used in cases of extreme non-compliance, i.e., throwing task materials, striking the trainer, etc.

Data Recording

The type of data recorded for each of the two prompting methods during assessment probes was rated correct and error responding. Data recorded during training portions of the sessions were different for each of the two prompting methods. Sample data recording sheets are provided in appendix 1. The data record sheets were used to summarize data from training and probe blocks. The trial by trial data sheet was used in order to allow for trial by trial reliability checks. Trainers recorded subject responses on a trial by trial basis in training blocks. Those data were then transferred to the Data Record Sheet.

Training data under the graduated guidance method consisted of the number of trials ending in reinforcement and the number of trials that required a time out procedure. Summing those two categories yielded the number of trails provided in each training block. The trainer also recorded the time spent in each training block. Training time was recorded on a continuous basis. The trainer started a stop watch the first time the cue for a task was delivered. The watch ran until an end-of-trial consequence was delivered with the cumulative time reading 2 minutes or more. The time exceeded 2 minutes if a trial was in progress when the cumulative time of 2 minutes was reached.

Data collected under the time delay method during training blocks consisted of anticipated corrects, wait corrects, anticipated errors, and non-compliance. Summing these categories yielded the total number of trials per training block. Time in training was accumulated as in the graduated guidance method described above.

Graduated Guidance

The graduated guidance technique requires the application of physical assistance in which the trainer manually directs the movements of the subject, using as much pressure as required, but reducing that pressure as the learner begins to perform independently (Foxx & Azrin, 1973). Foxx and Azrin (1973) have described the steps in graduated guidance as follows:

1. Exert no more force at any given moment than is needed to move the resident's hand in the desired direction.
2. At the start of each trial, use the minimal force (even a touch) and build up until the hand starts moving.

3. Once the hand starts to move, decrease the guidance instantly and gradually as long as the guided hand continues to move.
4. If movement stops during a trial, increase the guiding force instantly and gradually to the point where movement again results.
5. If the guided hand pushes against you in the direction away from the proper motion, apply just enough force to counteract that force, thereby keeping the resisting hand in a non-moving position.
6. As soon as the resisting hand decreases the degree of opposing force, instantly decrease the amount of force so that the resident's resistance is again just being counterbalanced.
7. When the guided hand stops actively resisting, immediately but gradually start again to use just enough force to move the guided hand.
8. Once a trial starts, continue to guide the hand until the response is completed; do not give up or interrupt before the final step.
9. At the end of the trial, give a reward.
10. The reward should be given together with the desired physical effect produced by the completion of the response.
11. When the reward is about to be given at the completion of the response, eliminate the guidance by withdrawing even touch contact and then give the reward.

12. Verbal praise should also be given during the guidance but only at those moments when the resident is actively participating in the movement and never while he is resisting or completely passive. [pp. 37 & 38]

When the guidance has been faded to a light touch, shadowing or spatial fading are recommended by Foxx and Azrin (1973) to further reduce assistance. Shadowing refers to following the pupil's hand(s) at a fraction of an inch, but not touching, and then gradually increasing the distance between the hands of the teacher and those of the pupil. In spatial fading, the locus of the physical prime is shifted further and further from the initial locus of guidance. If, for example, the initial locus of a physical prime was the pupil's wrist, the instructor might move the prime to the pupil's elbow, and then the shoulder. Contact between teacher and pupil is then eliminated entirely. This study utilized spatial fading to reduce assistance. Spatial fading was chosen over shadowing to maintain consistency with earlier physical guidance of the subject. This results in fading occuring across only the physical/visual dimension of prompts, whereas shadowing fades through the visual dimension only.

Time Delay

The time delay procedures employed in this study followed a constant delay format (Kleinert & Gast, 1981). There were two delay levels, concurrent and 4 seconds. The constant delay method has been employed by Halle, Marshall, & Spradlin (1979), Johnson (1977), and

Kleinert & Gast (1982). The delay of 4 seconds, also used by Johnson (1977), was employed in this study. The 4 second delay level falls between the 3 and 5 second levels recommended by Walls et al. (1982) as reasonable delays between the natural stimulus and the trainer's prompt. The concurrent level was employed for the first three trials of each training session. At the concurrent level the verbal cue to begin the task and the training prompt, full physical assistance, were delivered simultaneously. On the fourth trial, and all subsequent trials in the session, the 4-second level was used. At the 4-second level the trainer presented the verbal cue to begin the task and then timed the latency to the initiation of the subject response. If the subject did not initiate the response within 4 seconds the trainer then delivered the prompt. If the subject initiated the response within 4 seconds but deviated from a correct response the trainer provided physical assistance to complete the response correctly. If the subject initiated within 4 seconds and completed the response correctly the trainer provided no assistance and delivered reinforcement.

Response Prompts Employed Outside the Experiment

Since the pupose of this study was to investigate the relative efficacy of two response prompting methods in an instructional intervention, it was possible that prompting methods already in use in the classrooms could have influenced treatment effects. In order to address this potential confound, an assessment of the prompting methods employed in the classrooms was conducted. Evaluation of those methods was conducted through observations of subjects to determine the type of response prompts utilized. The observations were conducted three times throughout the course of the study for 30 minutes for each of seven subjects. Two observers rated each interaction with a teacher that took place during the 30 minute observation period. The observers indicated whether the response prompts applied to the subject were graduated guidance, time delay, decreasing assistance, increasing assistance, or not identifiable as any of the four major response prompting methods. In some instances it was necessary to ask the teacher or other person conducting the program for additional information in order to make a judgment regarding what prompt method was used. For instance, it was possible to observe one session and see only one level of assistance provided to the subject. Without knowing the next level of assistance to be employed it was impossible to identify how the prompt was to be faded, and therefore which prompting method was being employed. In this instance the observer had to ask what level of assistance would be employed next to accomplish fading of the trainer prompt.

Dependent Measures

The dependent measures in this study were the slope of the line of progress of charted data, total instructional time to aim, and the number if trials to aim. The slope of the line of progress served as the dependent measure for the six pairs of tasks trained. The slope was calculated for the 20 data points representing performance through five training sessions. The training sessions were limited to five because schools partcipating in the study were concerned that the students serving as subjects not be removed from regular educational activities for extended periods of time. In attempting to address the concern of the schools, a number of sessions was selected that would yield an adequate number of data points for analysis but not be considered burdensome to the schools.

Total instructional time to aim and trials to aim served as the dependent measures on the last pair of training tasks. This last pair of tasks was taught to aim, or limited to 20 daily sessions. The measures of time to aim and trails to aim were chosen as dependent measures for the last two tasks due to their perceived importance to teachers. While trials to criterion may differ as a result of the method employed, the total instruction time to criterion yields an accurate indicator of the method's overall effectiveness in terms of a variable about which most teachers are concerned. Since a teacher's most valuable resource to be allocated to his/her students is instructional time, it was considered likely that reporting the effectiveness of teaching methods on this dimension would have more impact on teacher acceptance of experimental results. Total instructional time was computed by keeping a record of training session times on a stop watch. The session time was planned to be 10 minutes. Once a subject reached aim on a probe for a particular task, summing the individual session times yielded the total instructional time to aim for that task. A count of each training trial presented to subjects was kept during each session. Once a subject reached aim summing the trials from each session yielded the total trials to aim for each task.

Maintenance Probes

Probes were conducted at the end of each week of training, starting with the second week, on all skills for which instruction was completed for at least one week. This procedure yielded a lagged schedule of skill maintenance probes across the duration of the study. For example, both tasks in the first pair were probed for maintenance at the end of the second week, and every week until the end of the study. Both tasks in the second pair trained were probed for maintenance at the end of the third week and every week until the end of the study. Thus there were eight maintenance probes for pair one, seven for pair two, six for pair three, etc. A maintenance probe was conducted on all pairs of tasks at the conclusion of the study. The scheduling of maintenance probes in this fashion, rather than only conducting one maintenance probe at the conclusion of the study or at some point in time after the completion of the study, allowed for the evaluation of changes in maintenance over time, rather than just at one point in time. Maintenance probes were conducted in the same manner as assessment probes.

Reliability

Reliability of data collection was insured by training observers prior to their participation to a criterion of 95% agreement and by conducting frequent reliability checks. Of the 3 reliability observers employed, 2 were graduate students in special education and the third a teacher with a master's degree in special education. All observers were trained by the author in approximately a 1.5 hour session explaining the procedures employed in the study and through practice reliability sessions during the first 3 days of the study. All observers met the 95% agreement criteria in their first practice session. Reliability was conducted 1x per week for one subject at each training site. 40 reliability checks were conducted across 14 out of the 16 tasks trained. All subjects were observed during the study. Range of subject observations was 2-10. Reliability checks were randomly scheduled during sessions across tasks and subjects throughout the study. During reliability sessions, 2 observers were positioned to overtly observe the trainer and subject behaviors, but were unable to observe each other's scoring. Inter-observer reliability was computed as: (agreements x 100)/agreements + disagreements.

In addition to determining data collection reliability, the reliability with which training procedures were applied in each condition was assessed (Billingsley, White, & Munson, 1980). Randomly scheduled observations of treatment implementation were used to insure that procedures were employed as specified. Reliability checks compared written program/treatment plan descriptions with the observed behavior of the subject trainer. As opposed to the total trial calculation of reliability used by Billingsley et al. (1980), this study computed reliability on a point-by-point basis. The elements of procedures evaluated were: delivery of cues; application of prompting procedure; and delivery of consequation. Procedural reliability served to demonstrate that the observed comparative effects were a function of the treatments as described. The same number of subjects and tasks were observed for procedural reliability as was reported for reliability checks on performance data.

Since both the graduated guidance and time delay conditions, as employed in this study, utilized a full physical assistance prompt, the difference between the two methods was defined by how the prompt was faded. In the graduated guidance method, the prompt was faded by a lessening of the intensity of assistance provided to the learner. The fading in the time delay method was acomplished through the insertion of a delay between the stimuls that is to ultimately control the response and the application of the prompt. The intensity of the physical assistance provided under the time delay method was not lessened under fading. The expectation was that, at some point, the subject would "anticipate" the prompt and respond in the presence of the natural stimulus, thereby accomplishing the transfer of stimulus control.

Procedural reliability of the time delay method was established through the use of independent observation of the trainer's application of the procedure as prescribed in written plans. The procedure essentially amounted to the provision of a cue to begin the task, the application of the prompt procedure, and the delivery of a consequence. The prompt procedure in time delay was different depending on whether the trial observed was one of the first three in the session or not. The first three trials in each session were concurrent delay levels; i.e. there was no delay between the natural stimulus and the prompt. On all subsequent trails in a session there was a 4 second delay between the provision of the natural stimulus and the prompt. It was the delay between the natural stimulus and the prompt that readily distinguished, through observation, the time delay method of prompting from the graduated guidance method.

Since the manner of fading in the graduated guidance method was accomplished through a lessening of intensity of physical assistance it was difficult for an independent observer to be able to discriminate whether this lessening of assistance was occuring or not. In order to account for this difficulty there was a supplementary procedural reliability check employed on the graduated guidance method. In addition to observation of the trainer's delivery of cues, application of the graduated guidance prompt, and delivery of consequence, the trainer's use of the graduated technique was periodically assessed by comparison to a standard protocol. This comparison was accomplished through the procedure of the independent observer playing the role of a subject receiving training. The independent observer responded to the task being trained according to a prearranged script. This script contained behaviors such as stopping movement, resisting the trainer's assistance, and actively making the required task movements without the need for the trainer's assistance. All of these behaviors required different responses on the part of the trainer that were not be readily observable. After each trial the independent observer marked the behavior of the trainer as being either correct or incorrect according to the response that should have been made according to the script. Reliability was computed as: agreements with script x 100/agreements + disagreements.

Results Task Pairs

Of the 25 TPS items, 18 were pooled to form approximately equivalent pairs. Seven items were eliminated fron further analyses because they either did not lend themselves to physical prompting or they could not be paired with at least one other equivalent item.

As noted in the Methods section, sets of 25 cards, each consisting of a picture of the item on one side and a written desription of the item on the other side were sent to 15 independent raters who were experienced in the education of persons with severe handicaps. Ten of the raters were on the faculty, or were grant coordinators, at three universities, three were working for a business employing workers with severe handicaps, one was a teacher of students with severe/profound handicaps and one was a private vocational consultant to programs employing workers with severe handicaps. Each rater had at least 5 years experience working with persons with severe handicaps.

The raters were instructed to place the cards they were sent in an ascending order of difficulty. The raters rankings of the TPS items were used to complement the results from the signs test on the perfrormance of 149 subjects with severe handicaps on the TPS items. The rankings of the raters for each potential pair were subjected to a matched sample t test. If the results of the t test were significant at the .05 level it was assumed that the raters perceived some difference in the degree of difficulty of the 2 items in the potential pair. If, however, the results of the t test were not significant than it was assumed that the raters perceived not differnce in the difficulty of the 2 items.

Based on the results of the signs test and the raters rankings, six primary pairs of items were formed. Four additional pairs were formed as substitutes for pairs on which subjects perfromed at aim during pretesting. One subject also required the use of substitute items due to an inability to perform some items because of sensory disabilities. This resulted in 10 pairs of items being formed. Table 2 presents the results of the analysis of TPS items and t tests performed on the raters rankings of those 10 pairs.

Insert Table 2 about here

Subjects 1, 2, 6, and 7 were trained on pairs 1-6. Pair 8 was substituted for pair 2 with subject 3 due to pretest perfromance exceeding aim on pair 2. Subject 4 had pairs 7, 8, and 9 substituted for pairs 1, 2, and 5 repectively due to severe visual disabilities that made it impossible for him to perform the tasks in these pairs. Subject 5 had pairs 7, 8, 9, and 10 substituted for pairs 1, 2, 4, and 5 due to pretest performance exceeding aim on those pairs. Subject 5 was only trained on 5 pairs because it was impossible to form any other pairs from the TPS items that this subject was not already performing at aim.

Of the 10 pairs formed, 5 display high zero values and approximately equal positive and negative values which would be suggestive of approximately equivalent difficulty (pairs 2, 3, 5, 6 and 10). These 5 pairs also resulted in non-significant t tests on the raters rankings. Three pairs (1, 7, and 8) had high zero values and approximately equal positive and negative values, but resulted in significant t tests on the raters rankings. This would indicate that the TPS item analysis supported these items as being approximatley equal in difficulty, but the raters rankings indicated a significant ranking of one item as more difficult than the othewr in the pair. Finally, two pairs (4 and 9) resulted in neither the TPS analysis nor the raters rankings supporting the items in those pairs as being approximately equal in difficulty. In sum, some paris were more suggestive of equivalent difficulty than others. The results of an analysis of the slopes of lines of progress obtained under the two treatments will be presented subsequently in this chapter. These analyses will attempt to clarify any confounding due to the non-equivalence of some task pairs.

Reliability

Reliability data were collected on five different aspects of the study. First, reliability of data collected during subject training was assessed. Second, procedural reliability data were collected for both treatment conditions. Third, a supplementary procedural reliability check was conducted under the graduated guidance treatment. This supplementary procedure called for an independent observer to act in the role of a subject and behave in a manner prescribed by a predetermined script. This observer then recorded the trainers guidence as being correct or incorrect application of the graduated guidance procedure based on the behavior called for in the script. Fourth, data were collected on the usage of prompting techniques by the subject's teachers outside of the experiemental setting. Finally, reliability data were collected on the number of reinforcers delivered and the number of trials conducted under each treatment condition.

The author served as observer for data collection reliability. Procedural reliability checks were conducted by the author, two doctoral students in special education and the classroom treacher at one of the experiemental sites. Supplemental checks for procedural relaibility under the graduated guidance treatment were conducted by the author, the two doctoral students in special education and the classroom teacher at one of the experiemental sites. Data collection and relaibility for response prompting methods used outside the experiemental conditions were conducted by the author and a doctoral student in special education. The collection of data and reliability observations for the number of reinforcers and trials conducted under the two experiemental conditions occured within procedural reliability sessions and were conducted by the same reliability observers. A total of 40 reliability observations were conducted across the two training sites. Fourteen of the 16 tasks were included in those observations. Tasks 15 and 21 were not observed for reliability. Reliability observations conducted across subjects ranged from 2 to 10 observations per subject. with a mean of 5.5 observations per subject.

Data Reliability. Reliability of data are reported for each site, treatment, and for probe and training data. Probe data collected at Sorenson across 12 observations under the time delay treatment ranged from 88% to 100%, with a mean of 98%. Reliability of data collected during training sessions under time delay at Sorenson was always 100% across 11 observations. Probe data reliability under graduated guidance at Sorenson ranged from 60% to 100%, with a mean of 90% across 8 observations. The reliability of data collected during training sessions under graduated guidance at Sorenson ranged from 92% to 100%, with a mean of 99% across 8 observations. Reliability for probe data under time delay at Gordon Hauck Center ranged from 93% to 100%, with a mean of 99% across 13 reliability obervations. Training data relaibility ranges from 90% to 100%, with a mean of 98% across 12 reliability obervations. Relaibility for probe data under graduated guidance at Gordon Hauck Center ranged from 66% to 100%, with a mean of 96% across 11 reliability observations. Training data reliability ranged from 89% to 100%, with a mean of 98% across 11 observations.

Procedural Reliability. Procedural reliability for time delay consisted of observing trainer behaviors in seven categories. Trainers were observed to determine whether their behaviors were in accord with those prescribedin the plan sheets for the following behaviors: layout of task materials; delivery of task cues; delivery of consequences for correct and error responses; delivery of the prompt; session times for training and probe blocks; timing of the 4 second delay level; and response to anticipations, i.e., when the subject reponded prior to the trainer prompt. Procedural reliability for the graduated guidance condition consisted of observing trainer behaviors in the following six categories: Layout of task materials; delivery of taks cues; delivery of consequences for correct and error responses; delivery of the prompt; session time for training and probe blocks; the timing of prompt delivery, i.e., subject was to perform task correctly or trainer was to propmt immeadeately. The results of procedural reliability observations for all categories of trainer behavior, except the timing of the propmt delivery under time delay, are presented in Table 3.

Insert Table 3 about here

The results of reliability observations of the timing of the delay level in the time delay condition indicated that the 0 second delay was delivered correctly 88% of time as reported by both observers at Gordon Hauck, based upon 9 observations. The 0 second delay was correctly delivered 100% of the observations as reported by both observers at C. O. Sorenson, based upon 15 observations. At Gordon Hauck Cneter observer 1 reported the 4 second prompt delay actually occured within 3.5 to 4.5 seconds 70% of the observations and within 3 to 5 seconds 30% of the observations., based on 10 observations. Observer 2 reported the prompt delay actually occured within 3.5 to 4.5 seconds 43% of the observations, within 3 to 5 seconds 43% of the observations and within 2.5 to 6.5 seconds 14% of the observations, based on 7 observations. Observer 1 at C.O. Sorenson reported that the 4 second delay actually was delivered within 3.5 to 4.5 seconds 53% of the observations, within 3 to 5 seconds 31% of the observations and within 2.5 to 6.5 seconds 16% of the observations, based on 19 observations. Observer 2 at C.O Sorenson reported the delay occured within 3.5 to 4.5 seconds 60% of the observations, within 3 to 5 seconds 25% of the observations and within 2.5 to 6.5 seconds 15% of the observations, based on 20 observations.

Graduated Guidance Supplemental Reliability. Due to the fact that certain aspects of the graduated guidance technique are not readily observable, i.e., providing assistance only when the subject is not moving voluntarily, conteracting movement in the wrong direction with just enough force to correct the movement etc., a supplemental procedure was used to determine the extent to which trainers were employing those techniques correctly. During these supplemental checks the relaibility observer performed the role of a subject in training. The author developed a script that the observer was to follow while acting as a subject. For example, the script might have directed the observer to perform independently to a spefic point in a task and then stop. The correct trainer response to this situation is to immeadeately apply wnough pressure to move the obserever's hands in correct performance of the task. Similarly, the observer may have had a script that directed him to not initiate any movement until a certain point in a task was reached. In this instance the correct trainer response is to assist until the observer initiated independent movement and then to stop providing assistance as long as the observer was performing independently. Eighteen seperate scripts were used across 3 observations at each site. The observer scored the trainer at Gordon Hauck as responding correctly on 17 of 18 trials for a reliability of 94%. The observer scored the trainer at C.O. Sorenson as responding correctly to all 18 trials for a reliability of 100%.

Prompts Applied Outside Experiemental Conditions. The type of prompts that teachers used with subjects outside of the experiemental conditions could result in additional practive with one of the prompting methods used in this study. Subjects were observed outside of training sessions to determine if they were consistantly recieving prompts from their teachers in either the time delay or graduated guidance methods of prompting. Each subject was observed outside of experiemental conditions for a total of 90 minutes, except subject 6 who was observed for 30 minutes and subject 7 who was observed for 106 minutes by observer 1 and 100 mihnutes by observer 2. Subjects 1, 2, 3, and 5 were observed on three seperate occaisons for 30 minutes. Subjects 4 and 6 were observed on only one occaison due to absences. Subject 7 was observed on four seperate occaisons. Each observation was deivided into 2 minute intervals for a total of 15 intervals if a full 30 minute observation was completed. Each of the observers watched the subject from a distance of 3 to 4 meters throughout the observation period and remained 7 to 8 meters away from each other. Each time an observer witnessed a prompot being delivered by the subject's teacher or an aide in the classroom he recorded it as either time delay, graduated guidance, increasing assistance, decreasing assistance or not identifiable as one of these four. If no prompt was observed for an interval the category N.R. was recorded. Table 4 represents the results of observing the prompts delivered to subjects outside the experiemental conditions.

Insert Table 4 about here

Examination of Table 4 reveals that no instances of time delay prompts being delivered outside of experiemental conditions. Observer 1 recorded 13 intervals in which graduated guidance occured while observer 2 recorded 11 intervals in which graduated guidance occured outside experiemental conditions The most frequently recorded prompt technique was increasing assistance, which was recorded in 49 intervals by observer 1 and 51 intervals by observer 2. Inter-observer relaiabilities for recording prompts outside of experiemental conditions are reported in Table 5. Based on these observations subjects did not appear to have any experience with the time delay method of prompting and only minimal experience with graduated guidance.

Insert Table 5 about here

Rate of Reinforcers and Trials Presented. Table 6 presents the results of observations of the rate of reinforcers and trials per minute during training blocks under each of the two treatment conditions. These data were collected during procedurtal reliability observations and under the same conditions as the procedural reliability checks. Each observer recorded the number of times a trainer delivered what was presumed to be a reinforcer to a subject during a training block. Intra-chain, as well as end of chain presumed reinforcers were recorded. Any event that was defined as a reinforcer on the subject's plan sheet was recorded, e.g., verbal priase, edible, etc. If verbal praise and an edible were delivered to the subject only one reinforcing episode was recorded. Each observer also recorded the number of trials conducted during each training block. A trial was the intervasl between two successive task cues.

Insert Table 6 about here

The data in Table 6 for rate of reinforcers was computed by dividing the number of reinforcers by the training time recorded. Agreement was obtained by dividing the smaller rate by the larger X 100. Rate of trials conducted was computed using the same formula but substituting number of trials conducted for presumed reinforcers delivered.

Inspection of the data in Table 6 reveal that the rate of trials conducted under the two treatment conditions was highly similar, slighly under 3 trials per minute under each condition with very high inter-observer reliability. Rates of presumed reinforcers per minute, however, did differ between the two conditions. Slighly less than 3 reinforcers per minute were recorded under the graduated guidance condition with slightly less than 2 reinforcers per minute under the time delay treatment condition. Although not supported thorugh observation this difference in rate of reinforcers per minute is probably due to the fact that intra-chain reinforcers are encouraged under the graduated guidance method of prompting but not under time delay.

Randomization Test Results

Slopes were computed for all correct and error responses ontained during assessment probes. The median slope method of trend estimation was chosen due to its higher predictive validity as compared to other methods of trend estimation, e.g., split-middle, quarter-intersect, regression (White, 1972). All slopes obtained from the assessment probe data for all subjects are provided in Appendix 2.

The slopes were subjected to a randomization test (Edgington, 1980) to determine if there was any differential performance under the two treatment conditions. The randomization test was employed rather than a parametric statictical test because the data from this study violate the assumption of data points being independent of each other. Since the data in this study are repeated measures of performance within subjects they are serially dependent and therefore cannot be subjected to inferential tests of significance. Additionally, the subjects in this study were not selected randomly which violates the assumption of random selection for the use of inferential statistics.

Randomization tests are used to determine the significance of experiemental results without reference to significance tables. Rather than comparing the statistical test results to the critical values in the significance tables the experiemtner permutes the experiemental data into all possible combinations under the treatments applied. These permutations provide the universe of statistical values agianst which experiemental results are compared. If, for example, an experiement has 252 possible data permutations, of which only 10 yield a test staticitc value equal to or greater then the actual obntained values, then the results yield a significance value of .04 (10/252).

The median slopes obtained from the performance of the 7 subjects during assessment probes were subjected to a within subjects randomization test. Both the slopes for correct and error rates were tested. The tests were computed to determine the significasnce value for any difference in performance under the graduated guidance and time delay treatment conditions.

All subjects, except number 5, were trained on 6 tasks under each of the treatment conditions. Subject 5 was trained on 5 tasks under each treatment. In the case of subjects who were trained on 6 tasks under each treatment there are 64 possible data permutations resulting from the 12 tasks permuted 2 at a time or 2 to the 6th. Subject 5 had 32 possible permutations resulting from 10 tasks permuted 2 at a time, or 2 to the 5th. In order to reach a significance value of .05 only 3 of the 64 permutations could be equal to or greater than the actual obtained value of a t test between the mean performance under the 2 treatments (3/64 = .046). In the of subject 5 only 1 of the 32 permutations could be equal to or greater than the obtained t value to reach a significance value of .05 (1/32 = .031).

The results of the randomization test for correct slopes are presented in Table 7. The significance values in Table 7 indicate that the null hypothesis of no significant difference between the performance under the time delay and grauated guidance treatments should be accepted as true. None of the significance values obtained from the randomization tests even approach the levels necessary to reject the null hypothesis. Subject 3, with a significance value of .25, had the lowest significance value which still indicated that the results had a 25% probability of being due only to chance. Certainly this level of significance value is insufficient to reject the null hypothesis for this subject. Since none of the other subjects had significance values better than subject 3 , the null hypothesis is accepted for all subjects based on the results of the randomization tests.

Insert Table 7 about here

Table 8 provides the results of the randomization tests conducted on the median slopes of error rates for all 7 subjects. The significance values in Table 8 support the acceptance of the null hypothesis for error rates. Based on these data there was no significant difference between the time delay and grauated guidance treatments on the rate of errors for all subjects.

Insert Table 8 about here

Performance by Pairs

Figures 2 through 8 represent the median slopes for correct rates for subjects 1 through 7. These figures are based on pairs 2, 3, 5, 6, and 10 only. These data are presented due to the strenght of the evidence supporting these pairs as being of approximately equivalent difficulty. Examining these pairs only, through visual inspection, may reveal treatment effects that were obscured in the randomization results by including performance on pairs that were of differential difficulty. Pairs 2, 3, 5, 6, and 10 all demonstrated patterns of performance from the TPS validity data that were suggestive of approximately equivalent tasks, e.g. high zero values and equal or nearly equal positive and negative values. These pairs also resulted in non-significant t tests when the rankings of expert raters were compared for these the tasks in these pairs. All slopes were converted to logs for presentation in Figures 2 through 8.

Insert Figures 2 to 8 about here

The performance of subject 1,represnted on Figure 2, shows that the slope of correct rates for pairs 2, 3, and 6 were accelarating faster under the graduated guidance treatment. The performance on pair 5 for subject 1 shows the correct slope as accelerating faster under the time delay trreatment. Subject 2's performance, represented in Figure 3, shows a decelerating correct slope for the graduated guidance task in pair 2, but a flat slope also under the time delay treatment for the other task in pair 2. The time dealy task in pair 5 showed an accelerating slope while the graduated guidance task had a flat slope. All other tasks in all pairs for subject 2 resulted in flat correct slopes. The performance of subject 3, in Figure 4, shows an accelerating correct slope for time daly in all pairs. Pairs 5 and

6 showed a decelerating slope for the graduated guidance task. The graduated guidance task in pair 3 showed an accelerating slope that exceeded the time delay slope in this pair, with a graduated guidance slope of X2.26 as compared to the time delay slope of X1.14. Subject 4 performance, in Figure 5, showed flat slopes for both tasks in pair 3 and an accelerating slope under time delay in pair 6 with a decelerating slope under graduated guidance. The performance of subject 5, represented in Figure 6, shows a decelerating slope under graduated guidance in pair 3 with an accelerating slope under the time delay task in this pair. The graduated guidance slope for the task in pair 10 was flat with a decelerating slope under time delay. Subject 6's performance, in Figure 7, shows an acceperating slope under the graduated guidance task in pair 5. ALl other slopes for subject 5 were flat. Subject 7's performance, as indicated in Figure 8, shows a decelerating slope under the time delay task in pair 3, with all other slopes being flat.

Based on the the data in Figures 2 through 8 it appears that subject 1's correct slopes were accelerating at a faster rate under the graduated guidance treatment in 3 of the 4 pairs. Subject 2' had only one accelerating rate under time delay and one decelerating rate under graduated guidance. Given that only one task in each of two pairs resulted in other than a flat slope it is difficult to come to nay conclusions concerning subject 2's tendency to perform better under either of the two treatments. Subject 3's performance indicated that on pairs 5 and 6 performance was better under the time delay treatment, but on pair 3 graduated guidance showed an accelerating slope of X2.26 to X1.14 for time delay. Subject 3's performance was therefore mixed in terms of any differential progress under the two treatments. Subject 4 was trained on only 2 of the 5 "best" pairs. Performance on pair 3 showed both slopes as flat. Performance in pair 6 indicated an accelerating slope under time delay, with a decelerating slope under graduated guidance. Since only one pair for subject 6 resulted in learning on at least one task it is not possible to determine if there was actually any conclusive difference in performance under the 2 treatments. Subject 5 was also trained on only 2 of the "best" pairs. The results of an accelerating slope under time delay and a decelerating slope under graduated guidance in pair 3, along with a decelerating slope under time delay and a flat slope under graduated guidance were inconclusive evidence for any differential performance in this subject also. Subjects 6 and 7 having only one accelerating and one decelrating slope, respectively, provided data not sufficient to come to any conclusions regarding better performance under either of the conditions, In summary, subject 1 performed better under the graduated guidance treatment in 3 of 4 pairs, subject 3 performed better under time delay on 2 of 3 pairs while it was not possible, based on the amount of performance data available. to come to any conclusions regarding the performance of subjects 2, 4, 5, 6, or 7 with regard to the 2 treatments.

Performance by Tasks in Pairs

Subjects performance by tasks in pairs was analized to determine if there was any tendency for performance on any tasks to be better under either the time delay or graduated guidance treatments. Figures 9 through 14 represent the slopes for correct responses for the tasks in pairs 2, 3, 5, 6, and 10. Once again, only these pairs were analized due to the stronger evidence for their approximately eqivalent difficulty.

Insert Figures 9 to 14 about here

Examination of the data in Figures 9 through 14 reveal no strong support for performance on any tasks being better under the time delay or graduated guidance treatments. In most instances it is difficult to come to any strong conclusions due to the small number of cases that actually resulted in accelerating slopes. Only pair 3, which each subject was trained on, resulted in performance that is slightly in favor of the graduated guidance treatment on task 24. Based on these results there was no difference in performance on any task under either of the treatments.

Maintenance

Figures 15 through 21 represent the maintenance of the rates achieved by subjects on the last day of rated performance. Maintenance rates were determined by computing the mean for performance on all probes conducted after training had been completed. The mean rate for maintenance probes was subtracted from the last rated day's performance to arrive at a difference between the last day's performance and the mean maintenance rate. The differences are presented in Figures 15 through 21. Tasks taught earlier in the study resulted in more maintenance probes being conducted than tasks completed later in the study. Only pairs 2, 3, 5, 6, and 10 were included in the maintenance analysis.

Insert Figures 15 to 21 about here

Subject 1's maintenance of end rates is presented in Figure 15. Rates on pair 2 continued to increase after training ended. The increase was slightly greater under time delay. Pair 3 resulted in a decline in end rates for both tasks, with the time delay task's rate declining more than twice as much as the graduated guidance task. The time delay task in pair 5 rate increased during maintenace while the graduated guidance task declined. Both tasks in pair 6 declined in rate during maintenance, with time delay showing only a slight loss in rate while the graduated guidance task loss was slightly greater. Threee of these four task pairs display slightly better maintenance of end rates under the time delay treatment.

Subject 2's maintenance is depicted in Table 16. Since it was only possible to compute a maintenance rate for 1 task in pair 5 for this subject, no conclusions can be drawn regarding any difference in maintenance rates under the 2 treatements.

Figure 17 represents the maintenance rates for subject 3. The minimal difference in maintenance rates on all task pairs does not support either treatment as resulting in superior maintenance of end rates.

Data on maintenance rates for subjects 4, 5, 6, and 7 are also minimal. Given the scanty data on the maintenance for these subjects no conclusions regarding differences in maintenance rates may be drawn from their performance.

REFERENCES

Azrin, N. H., & Armstrong, P. M. (1973). The "mini-meal" -a method for teaching eating skills to the profoundly retarded. *Mental Retardation*, *11*, 9-13.

Barlow, D. H., & Hayes, S. C. (1979). Alternating treatments design: One strategy for comparing effects of two treatments in a single subject. *Journal of Applied Behavior Analysis*, *12*, 199-210.

Bandura, A. (1980). *Principles of behavior modification*. New York: Holt, Rinehart, and Winston.

Bennett, D., Gast, D., & Wolery, M., & Schuster (1982). A comparison of two prompting procedures: Time delay and system of least prompts: A comparison in teaching manual sign production. *Education and Training of the Mentally Retarded*, *12*, 117-129.

Billingsley, F., White, O. R., & Munson, R. (1980). Procedural reliability: A rationale and an example. *Behavioral Assessment*, *2*, 229-241.

Billingsley, F.F., & Romer, L.T. (1983). Response prompting and the transfer of stimulus control: Methods, research, and a conceptual framework. *The Journal of the Association for the Severely Handicapped*, *8*, 3-12.

Close, D. W., Irvin, L. K., Prehm, H. J., & Taylor, V. E. (1979). Systematic correction procedures in vocational skill training of severely retarded individuals. *American Journal of Mental Deficiency*, *83*, 270-275.

Csapo, M. (1981). Comparison of two prompting procedures to increase response fluency among severely handicapped learners. *Journal of the Association for the Severely Handicapped*, *6*(1), 39-47.

Cuvo, A. J., Leaf, R. B., & Borakove, L. S. (1978). Teaching janitorial skills to the mentally retarded: Acquisition, generalization, and maintenance. *Journal of Applied Behavior Analysis*, *11*, 345-355.

DeVore, M. S. (1977). *Individualized learning programs for the profoundly retarded*. Springfield, IL: Charles C. Thomas.

Edgar, E., & Billingsley, F. F. (1974). Believability when N=1. *The Psychological Record*, *24*, 147-160.

Edgington, E. S. (1980). *Randomization tests*. New York: Marcel Dekker, Inc.

Falvey, M., Brown, L., Lyon, S., Baumgart, D., & Schroeder, J. (1980). Strategies for using cures and correction procedures. In W. Sailor, B. Wilcox, & L. Brown, (Eds.), *Methods of instruction for severely handicapped students* (pp. 109-133). Baltimore, MD: Paul H. Brookes.

Foxx, R.M., & Azrin, N.H. (1971). A rapid method of toilet training the institutionalized retarded. *Journal of Applied Behavior Analysis*, *4*, 89-99.

Foxx, R.M., & Azrin, N.H. (1972). Restitution: A method of eliminating aggressive-disruptive behavior of retarded and brain damaged patients. *Behavior Research and Therapy*, 10, 15-27.

Foxx, R. M., & Azrin, N. H. (1973). *Toilet training the retarded*. Champaign, IL: Research Press.

Gentry, D., Day, M., & Nakao, C. (1980). *The effectiveness of two prompt sequencing procedures for discrimination learning with severely handicapped individuals*. Unpublished manuscript, University of Idaho, Moscow.

Goodby, S., Gast, D., & Wolery, M. (in press). A comparison of: time delay and system of least prompts in teaching object identification. *Analysis and Intervention in Developmental Disabilities.*

Guess, D. (1980). Methods in communication instruction for severely handicapped persons. In W. Sailor, B. Wilcox, & L. Brown (Eds.), *Methods of instruction for severely handicapped students*. Baltimore, MD: Paul H. Brookes.

Haring, N.G., Liberty, K.A., & White, O.R. (1980). Rules for data-based strategy decisions in instructional programs: Current research and instructional implications. In W. Sailor, B. Wilcox, & L. Brown (Eds.), *Methods of instruction for severely handicapped students* (pp. 159-192). Baltimore, MD: Paul H. Brookes.

Halle, J., Marshall, A., & Spradlin, J. E. (1979). Time delay: A technique to increase language usage and facilitate generalization in retarded children. *Journal of Applied Behavior Analysis*, *12*, 431-349.

Hartmann, D. P. (1977). Considerations in the choice of interobserver reliability estimates. Journal of Applied Behavior Analysis, 10, 103-116.

Hersen, M., & Barlow, D. H. (1976). Single case experimental designs: Strategies for studying behavior change. New York: Pergamon Press.

Horner R. D., & Keilitz, I. (1975). Training mentally retarded adolescents to brush their teeth. Journal of Applied Behavior Analysis, 8, 301-309.

Hunter, J. D., & Bellamy, G. T. (1976). Cable harness construction for severely retarded adults: A demonstration of training technique. AAESPH Review, 1, 13.

Irvin, L. K., Gersetn, R., Bellamy, G. T., Taylor, V. & Close, D. W. (1980). The trainee performance sample: Improving vocational skill assessment of severely retarded adults. In R. H. Horner & G. T. Bellamy (Eds.), Habilitation of the severely and profoundly retarded: Volume III reports from the specialized training program (pp. 200-215). Eugene: Center on Human Development, University of Oregon.

Johnson, C. (1977). Errorless learning in a multihandicapped adolescent. Education and Treatment of Children, 1, 25-33.

Kazdin, A. E. (1976). Statistical analyses for single-case experimental designs. In M., Hersen & D. H. Barlow. Single case experimental designs: Strategies for studying behavior change (pp. 265-316). New York: Pergamon Press.

Kleinert, H. L., & Gast, D. L. (1982). Teaching a multihandicapped adult manual signs using a constant time delay procedure. *Journal of the Association for the Severely Handicapped*, *6*(4), 25-32.

Kratochwill, T. R. (Ed.) (1978). *Single subject research: Strategies for evaluating change*. New York: Academic Press.

Millenson, J. R., & Leslie, J. C. (1979). *Principles of behavioral analysis* (Rev. ed.). New York: Macmillan Pub.

Popovich, D. (1981). *Effective educational and behavioral programming for severely and profoundly handicapped students*. Baltimore, MD: Paul H. Brookes.

Renzaglia, A., & Snell, M. (1981). *Manual sign training for the severely handicapped: Time delay and a system of least prompts*. Unpublished manuscript, University of Virginia, Richmond.

Schriebman, L. (1975). Effects of within stimulus and extra stimulus prompting in discrimination learning in autistic children. *Journal of Applied Behavior Analysis*, *8*, 91-112.

Sidman, M., & Stoddard, L. (1967). The effectiveness of fading in programming a simultaneous form discrimination for retarded children. Journal of the Experimental Analysis of Behavior, *10*, 3-15.

Skinner, B.F. (1968). *The technology of teaching*. Englewood Cliffs, NJ: Prentice-Hall.

Snell, M. E. (1982). Teaching bed making to severely retarded adults through time delay. *Analysis and Intervention in Developmental Disabilities*, *2*, 139-155.

Snell, M. E. (Ed.), (1978). *Systematic instruction of the moderately and severely handicapped*. Columbus, OH: Charles E. Merrill.

Snell, M. E., & Gast, D. L. (1981). Applying time delay procedure to the instruction of the severely handicapped. *Journal of the Association for the Severely Handicapped*. *6*(3), 3-14.

Snell, M.E., & Smith, D.D. (1978). Intervention strategies. In M.E. Snell (Ed.), *Systematic instruction of the moderately and severely handicapped* (pp. 74-99). Columbus, OH: Charles E. Merrill.

Stremel-Campbell, K., Cantrell, D., & Halle, J. (1977). Manual signing as a language system and as a speech initiator for the nonverbal severely handicapped student. In E. Sontag (Ed.), *Educational programming for the severely and profoundly handicapped* (pp. 335-347). Reston, VA: The Council for Exceptional Children.

Striefel, S., Bryan, K. S., & Aikins, D. H. (1974). Transfer of stimulus control from motor to verbal stimuli. *Journal of Applied Behavior Analysis*, *7*, 124-135.

Striefel, S., Weterby, B., & Karlan, G. R. (1976). Establishing generalized verb-noun instruction following skills in retarded children. *Journal of Experimental Child Psychology*, *22*, 247-260.

Terrace, H.S. (1963). Errorless transfer of a discrimination across two continua. *Journal of the Experimental Analysis of Behavior*. *6*, 223-232.

Touchette, P.E. (1968). The effects of graduated stimulus change on the acquisition of a simple form discrimination in severely retarded boys. Journal of the Experimental Analysis of Behavior, 8, 39-48.

Touchette, P. E. (1971). Transfer of stimulus control: Measuring the moment of transfer. Journal of Experimental Analysis of Behavior. 15, 347-354.

White, O. R. (1972). Working paper No. 15 the prediction of human performance in the single case: an examination of four techniques. Euguene, OR: University of Oregon.

White, O.R., Edgar, E.B., Haring, N.G., Affleck, J.Q. to Hayden, A.H. (1981). Uniform Performance Assessment System. Columbus, OH: Charles E. Merrill.

White, O. R., & Haring, N. G. (1976). Exceptional teaching: A multimedia training package. Columbus, OH: Charles E. Merrill, Co.

Wilcox, B., & Bellamy, G. T. (1982). Design of high school programs for severely handicapped stuents. Baltimore, MD: Paul H. Brookes.

Zane, T., Walls, R. T., & Thuedt, J. E. (1981). Prompting and fading guidance procedures: Their effect on chaining and whole task teaching strategies. Education and Training of the Mentally Retarded, 16, 125-135.

TABLE 1

STUDIES COMPARING METHODS OF RESPONSE PROMPTING

Study	Nature of Task	Subjects	Prompting Methods	Dependent Measure	When Measurement Occurred	Major Results
Caspo 1981	Two Choice Discrimination	N=6	Decreasing Assistance vs. Increasing Assistance in Fluency Building Phase	Rate of Correct and Error Responses	1 min probe at end of each sessions.	Decreasing Assistance resulted in steady gain in correct rates, consistently low error rates. Increasing Assistance Initial drop in correct & rise in error rates - but overall response rates increased more rapidly than decreasing assistance.
Gentry, Day & Nakao (Note 1)	Two Choice discrimination	N=4 Age 15-21 S.Q. 16-33 All IQs 10 or	Decreasing Assistance vs. Increasing Assistance in Skill Acquisition Phase	Rate of Correct and Error Responses	1 min probe at end of each session	Increasing Assistance error rates accelerated, current rates decelerated Decreasing Assistance error rates decelerated, correct rates, accelerated.
Renzaglia & Snell (Note 2)	Manual Signs	N=8	Time Delay vs. Increasing Assistance	% Errors Trials to Criterion	Probe at the beginning of each session	Concluded that time delay and increasing assistance were of equal effectiveness
Benet, Gast, & Wolery (Note 3)	Manual Signs	N=3 Age 14-17 Severely Handicapped	Time Delay vs. Increasing Assistance	Number of sessions trials and errors to criterion and instructional time	N/A	Fewer sessions, trials & errors to criterion and less instruction time with the time delay method.
Goodby, Gast & Wolery (Note 4)	Object identification	N=3 Age 9-17 Severely Handicapped	Time Delay vs. Increasing Assistance	Number of sessions trials and errors to criterion and instructional time	N/A	Fewer sessions, trials & errors to criterion and less instructional time with the time delay method

Table 2

Results of TPS Item Analysis (N=149) and t Tests (N=15) for Task Pairs Ranked by Experts

Pair #	Item#	Description	Mean Difficulty	Zero Values	Positive Values	Negative Values	t Test
1	20	lids on boxes	1.61	103	23	23	t (14df)=3.60 p .005
	12	cap on penny	1.57				
2	5	red side up	1.43	90	30	29	t (14df)=.26 n.s.
	8	paper clip	1.43				
3	18	red angles	1.24	115	19	15	t (14df)=1.70 p .10
	24	connector/hole	1.20				
4	13	wing nut/bolt	1.14	95	34	20	t (14df)=5.94 p .0005
	22	washers on post	1.02				
5	4	locknut on bolt	.76	91	30	28	t (14df)=.32 n.s.
	17	broom clip	.70				
6	19	angles make box	.63	90	32	27	t (14df)=1.13 p .15
	10	nut on bolt	.61				
7	12	cap on penny	1.57	105	26	18	t (14df)=5.15 p .0005
	11	striped card	1.50				
8	5	red side up	1.43	94	30	25	t (14df)=9.46 p .0005
	21	rollers on post	1.35				
9	10	nut on bolt	61	95	37	17	t (df)=9.49 p .0005
	3	block under card	84				
10	15	block over, cap on top	.54	102	29	18	t (14df)=.38 n.s.
	10	nut on bolt	.61				

Table 3

Procedural Reliability

Time Delay
Gordon Hauck Center

Category	Materials	Cues	Consequences	Prompt Delivery	Probe Time	Train Time	Anticipations
# Sessions	9	13	13	12	13	12	12
Range	95-100	95-100	94-100	93-100	89-100	93-100	44-100
Mean	98%	99%	98%	98%	97%	98%	86%
C.O. Sorenson							
# Sessions	3	12	12	11	12	11	11
Range	100-100	91-100	85-100	92-100	93-99	95-100	75-100
Mean	100%	98%	93%	99%	96%	97%	97%

Graduated Guidance
Gordon Hauck Center

Category	Materials	Cues	Consequences	Prompt Delivery	Probe Time	Train Time	Prompt Timing
# Sessions	12	11	11	11	11	11	11
Range	100-100	85-100	85-100	79-100	93-100	94-99	89-100
Mean	100%	97%	95%	95%	98%	97%	97%
C.O. Sorenson							
# Sessions	4	8	8	8	8	8	8
Range	100-100	94-100	89-100	100-100	89-100	99-100	100-100
Mean	100%	99%	97%	100%	95%	99%	100%

Table 4

Occurence of Prompts Outside Experimental Conditions

Subject	Total Intervals		Time Delay		Graduated Guidance		Decreasing Assistance		Increasing Assistance		Not Identifiable		No Prompts	
	obs 1	obs 2	obs 1	obs 2	obs 1	obs 2	obs 1	obs 2	obs 1	obs 2	obs 1	obs 2	obs 1	obs 2
S1	45	45	0	0	0	0	0	0	5	4	0	0	40	41
S2	45	45	0	0	3	3	1	1	10	10	0	0	31	29
S3	46	46	0	0	2	2	0	0	15	16	0	0	29	28
S4	45	45	0	0	1	0	0	0	3	4	0	0	41	41
S5	45	45	0	0	0	1	0	0	4	4	0	0	41	40
S6	15	15	0	0	0	0	0	0	1	1	0	0	14	14
S7	53	50	0	0	7	5	0	0	11	12	0	0	35	33
Totals	294	291	0	0	13	11	1	1	49	51	0	0	231	226

Table 5

Percent Occurence Agreement Prompts Occuring Outside Experiment

Subject	Total Intervals	Time Delay	Graduated Guidance	Decreasing Assistance	Increasing Assistance	Not Identifiable
S1	100%	X	X	X	80%	X
S2	100%	X	100%	100%	100%	X
S3	100%	X	100%	X	94%	X
S4	100%	X	0%	X	75%	X
S5	100%	X	0%	X	60%	X
S6	100%	X	X	X	100%	X
S7	94%	X	50%	X	89%	X

Table 6

Reinforcement Rate and Trial Presentation Rate
Under Both Training Conditions

Graduated Guidance

	Obs 1	Obs 2	% Agreement
Reinforcement Rate per minute in training	2.93	2.91	99%
Trials presented per minute in training	2.93	2.93	100%

Time Delay

	Obs 1	Obs 2	% Agreement
Reinforcement Rate per minute in training	1.86	1.84	99%
Trials presented per minute in training	2.94	2.91	99%

Table 7.

Randomization Test Results on Slopes of Correct Rates

Subject	Number Equal or Above	Percent Equal or Above	Significance Value
S1	44	68.75	.6875
S2	32	50	.5
S3	16	25	.25
S4	32	50	.5
S5	30	93.75	.9375
S6	32	50	.5
S7	64	100	1.0

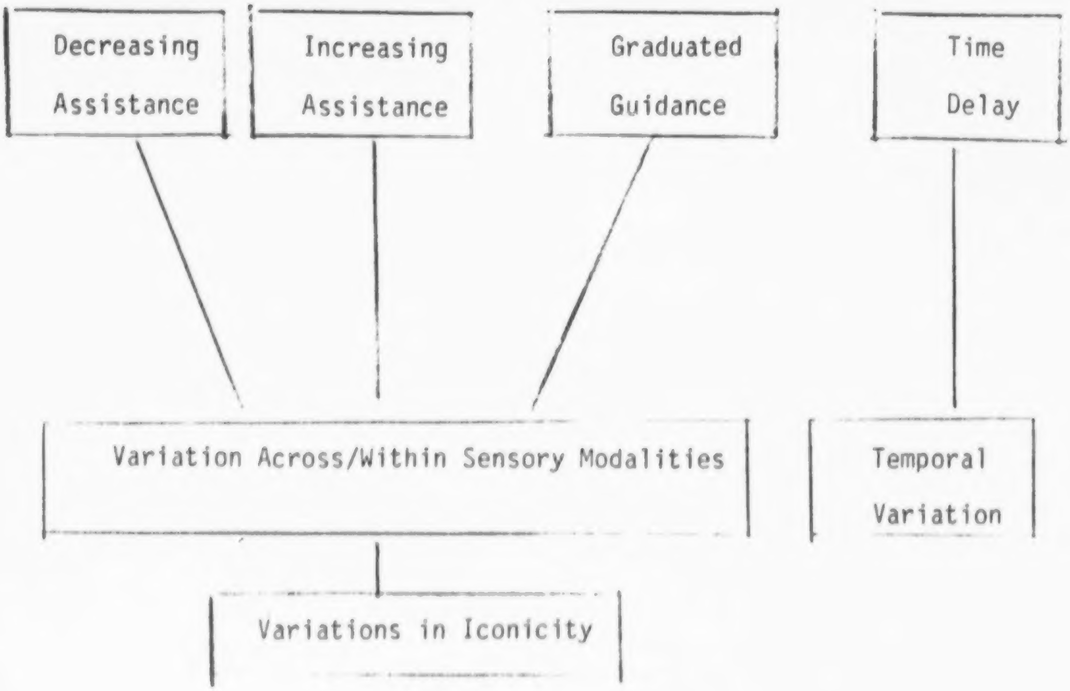
Table 6

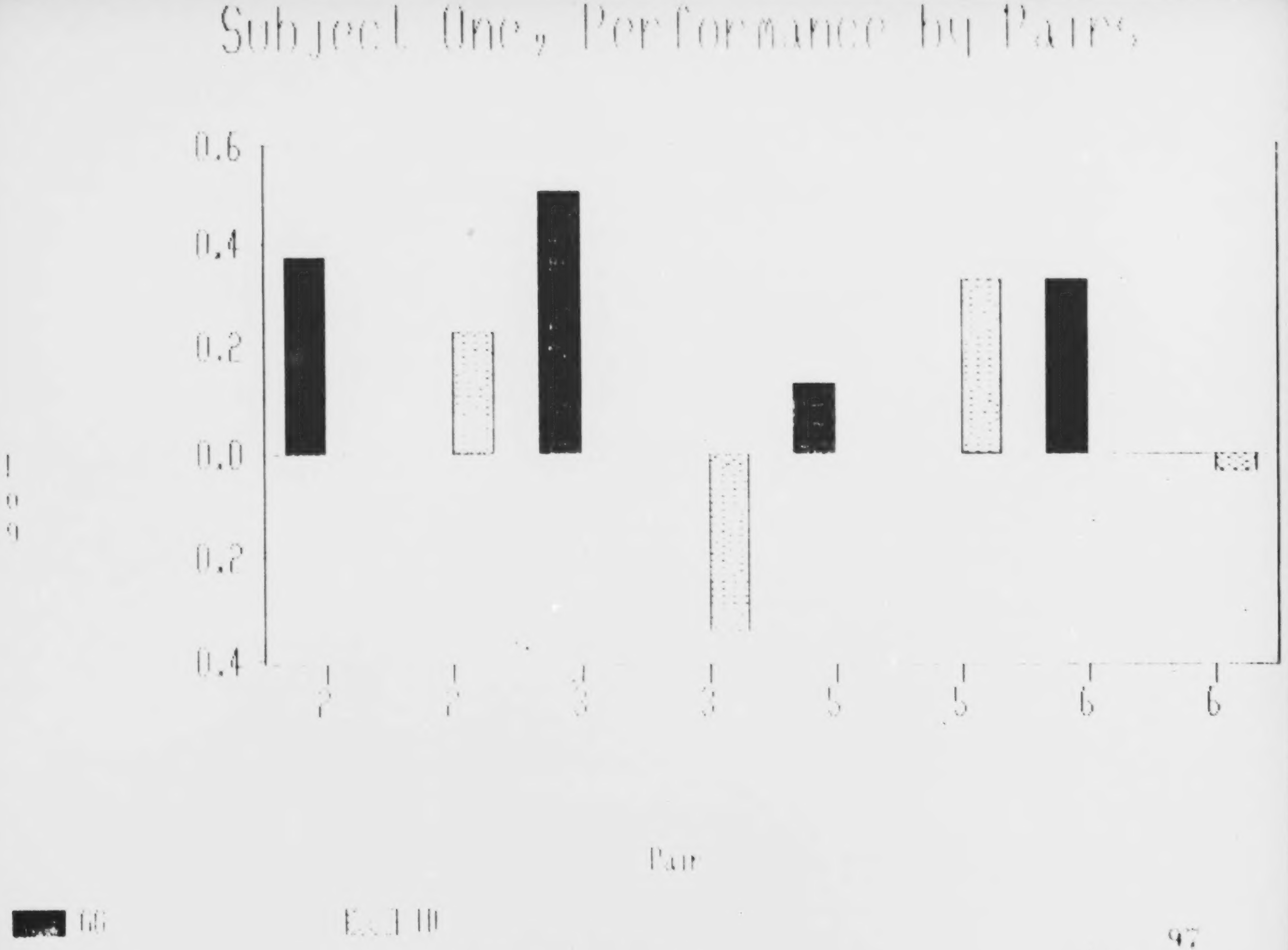
Randomization Test Results on Slopes of Error Rates

Subject	Number Equal or Above	Percent Equal or Above	Significance Value
S1	46	71.875	.71875
S2	64	100	1.0
S3	38	59.375	.59375
S4	30	46.875	.46875
S5	16	50	.5
S6	48	75	.75
S7	32	50	.5

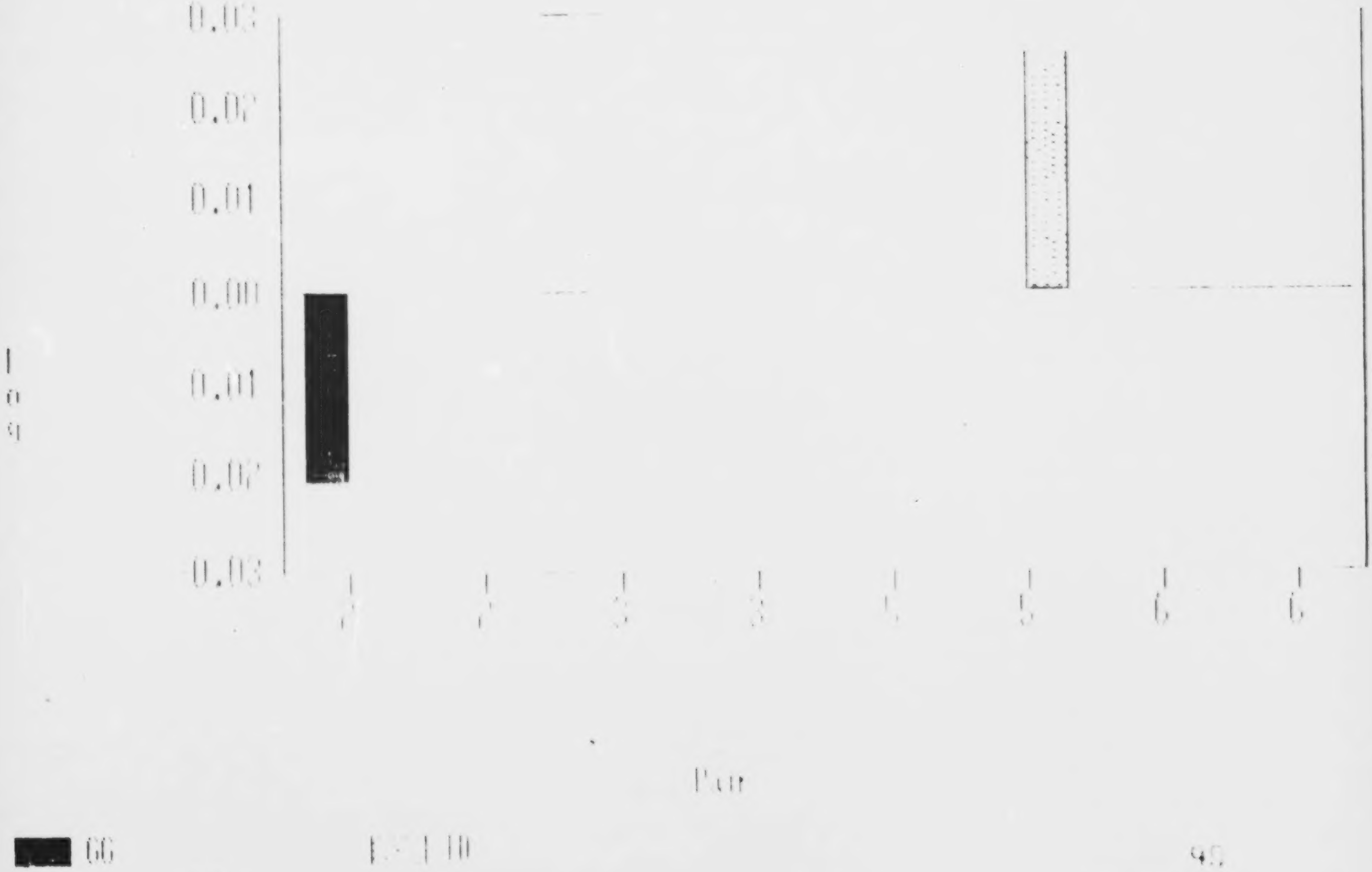
FIGURE CAPTION

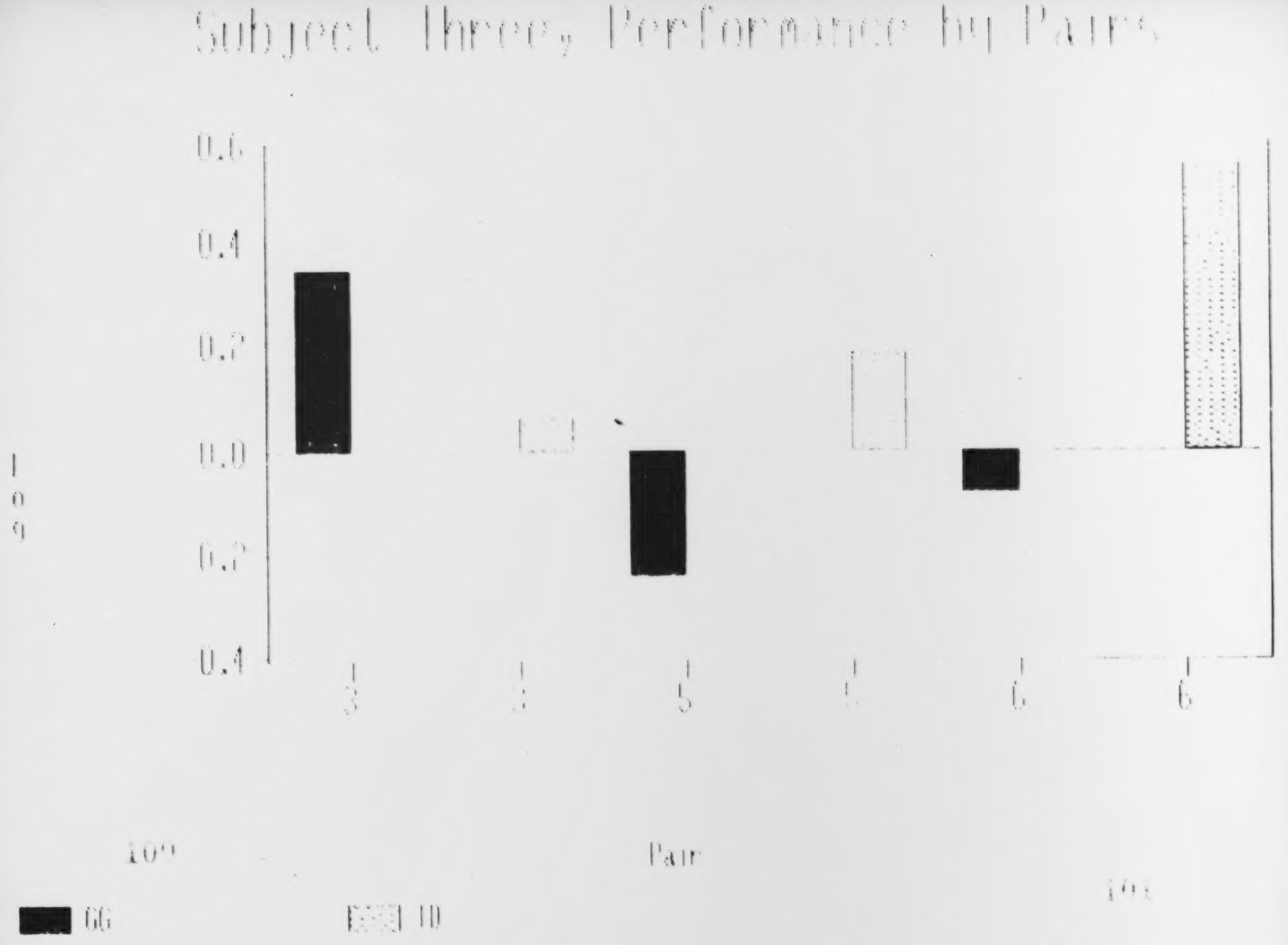
Figure 1. Method(s) of transfer in each major prompt fading technique.
Figure 2. Subject 1, performance by pairs.
Figure 3. Subject 2, performance by pairs.
Figure 4. Subject 3, performance by pairs.
Figure 5. Subject 4, performance by pairs.
Figure 6. Subject 5, performance by pairs.
Figure 7. Subject 6, performance by pairs.
Figure 8. Subject 7, performance by pairs.
Figure 9. Performance on tasks in pair 2.
Figure 10. Performance on task 18, pair 3.
Figure 11. Performance on task 24, pair 3.
Figure 12. Performance on tasks in pair 5.
Figure 13. Performance on tasks in pair 6.
Figure 14. Performance on tasks in pair 10.
Figure 15. Subject 1 maintenance by pairs.
Figure 16. Subject 2 maintenance by pairs.
Figure 17. Subject 3 maintenance by pairs.
Figure 18. Subject 4 maintenance by pairs.
Figure 19. Subject 5 maintenance by pairs.
Figure 20. Subject 6 maintenance by pairs.
Figure 21. Subject 7 maintenance by pairs.


Decreasing Assistance
Increasing Assistance
Graduated Guidance
Time Delay
Variation Across/Within Sensory Modalities
Temporal Variation
Variations in Iconicity

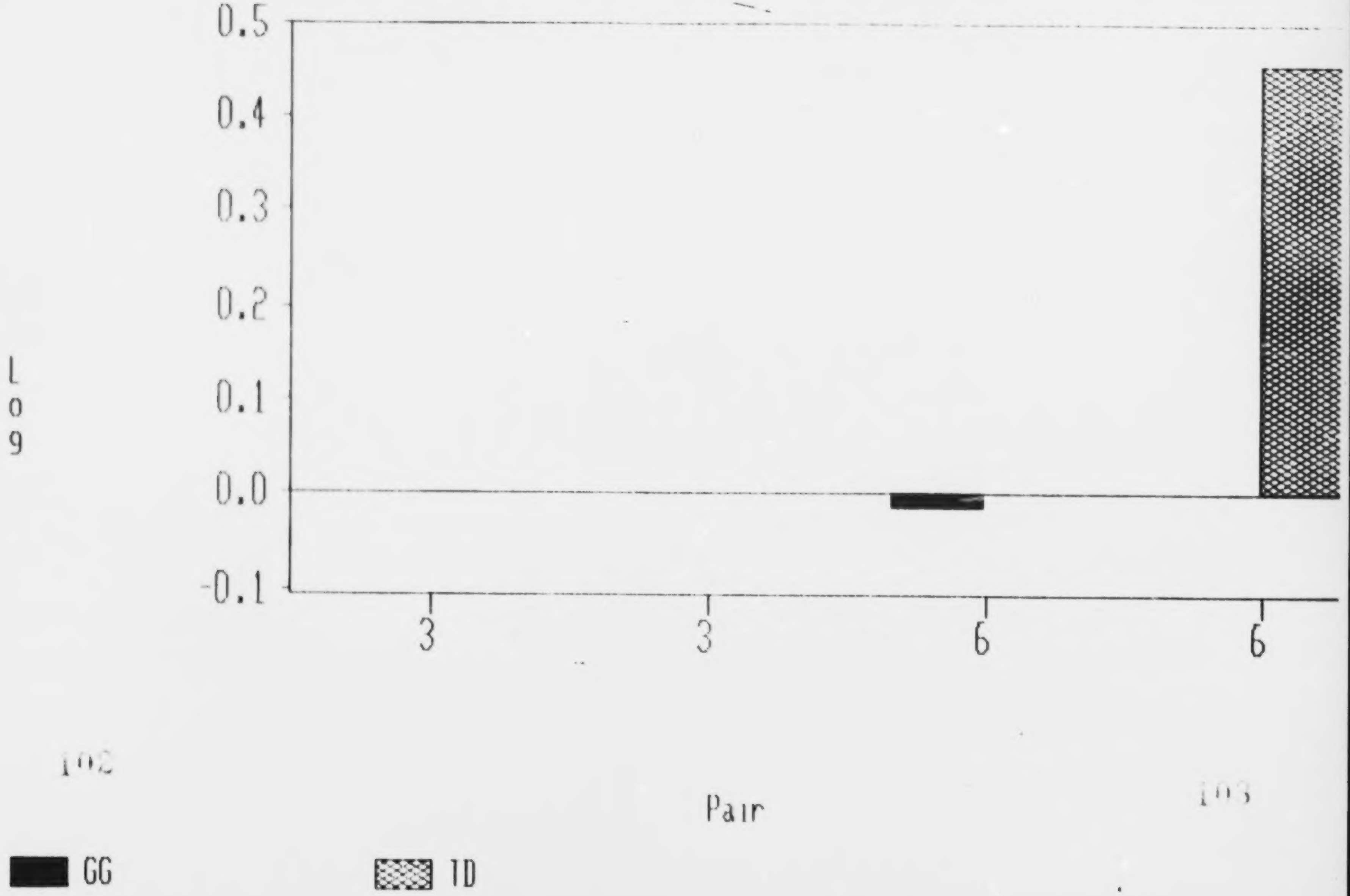

Subject One, Performance by Pairs
0.6
0.4
0.2
0.0
0.2
0.4
2
2
3
3
5
5
6
6
Pair
GG
ID

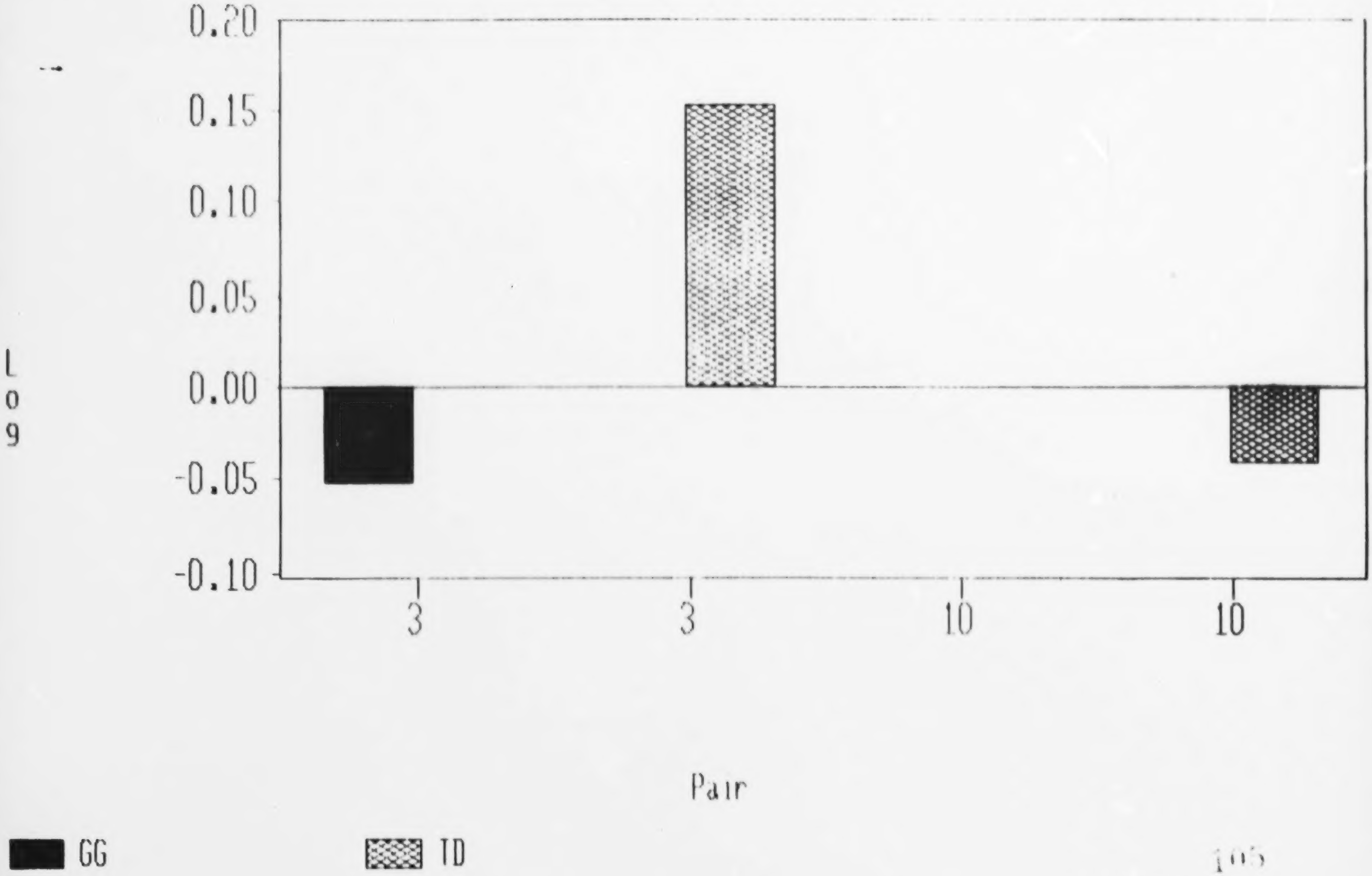
Subject Two, Performance by Pair



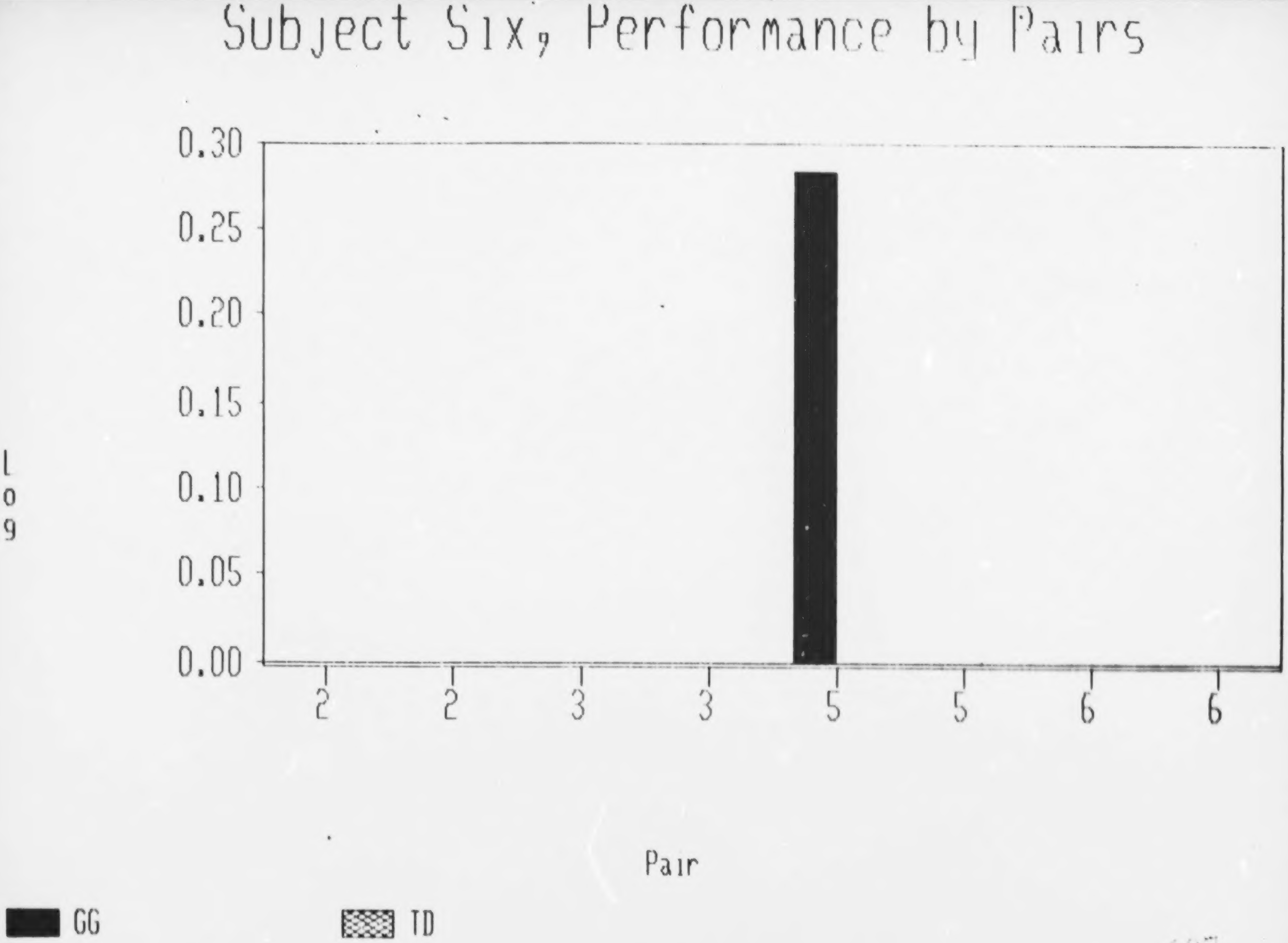
Subject Three, Performance by Pairs
0.6
0.4
0.2
0.0
0.2
0.4
log
3
3
5
5
6
6
Pair
100
101
GG
ID

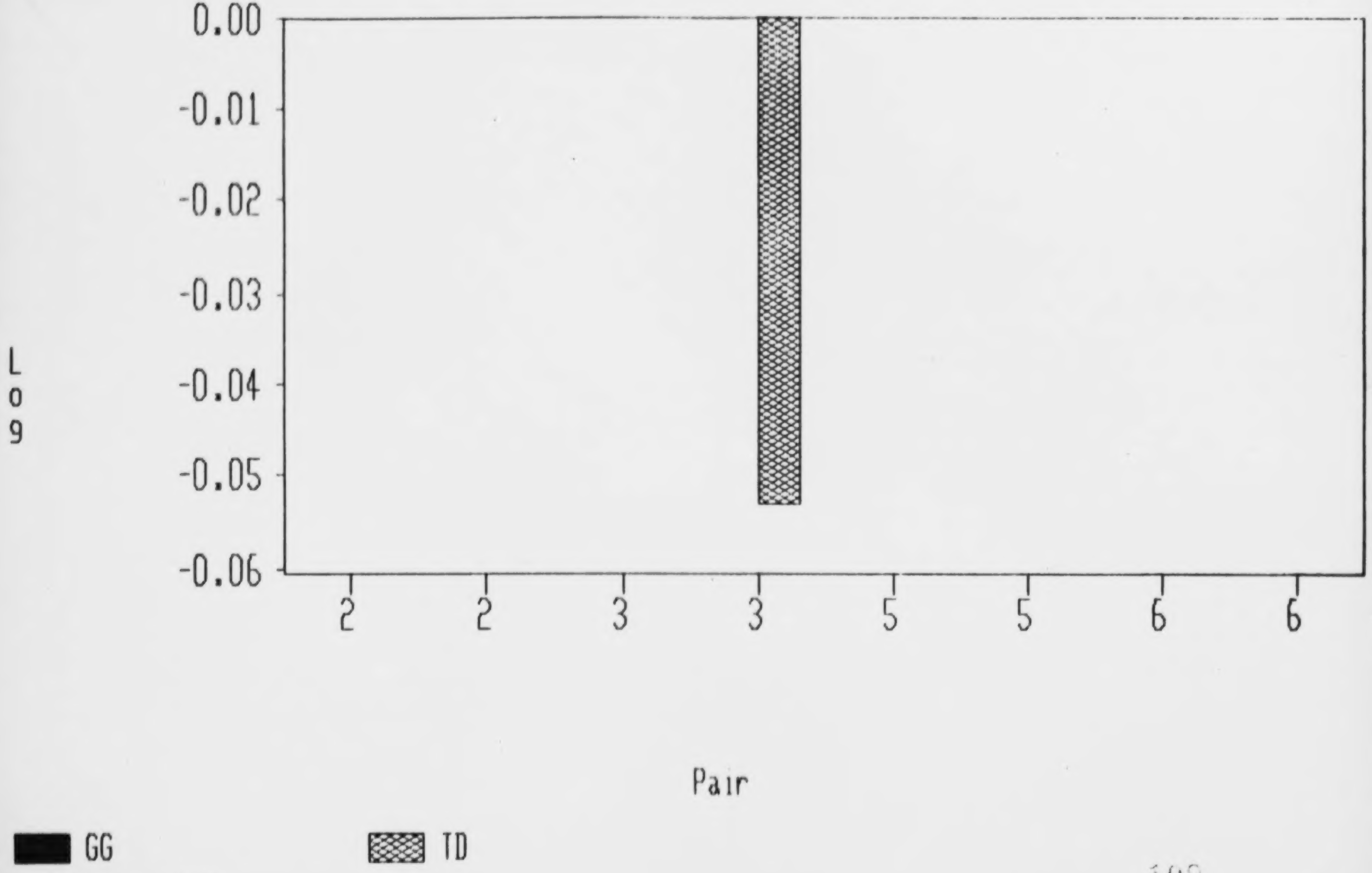
Subject Four, Performance by Pairs





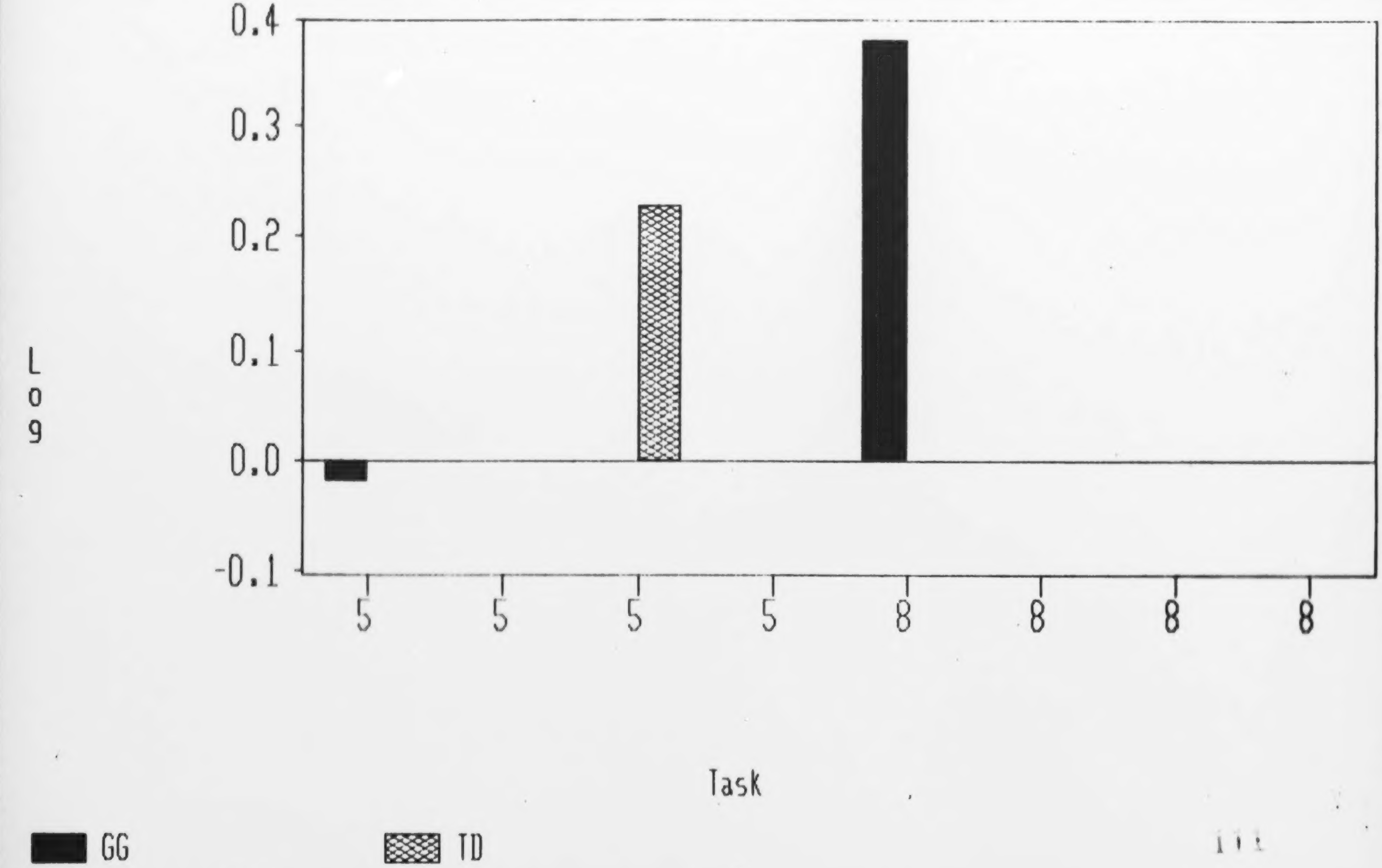
Subject Five, Performance by Pairs


Subject Six, Performance by Pairs
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Log
2
2
3
3
5
5
6
6
Pair
GG
TD

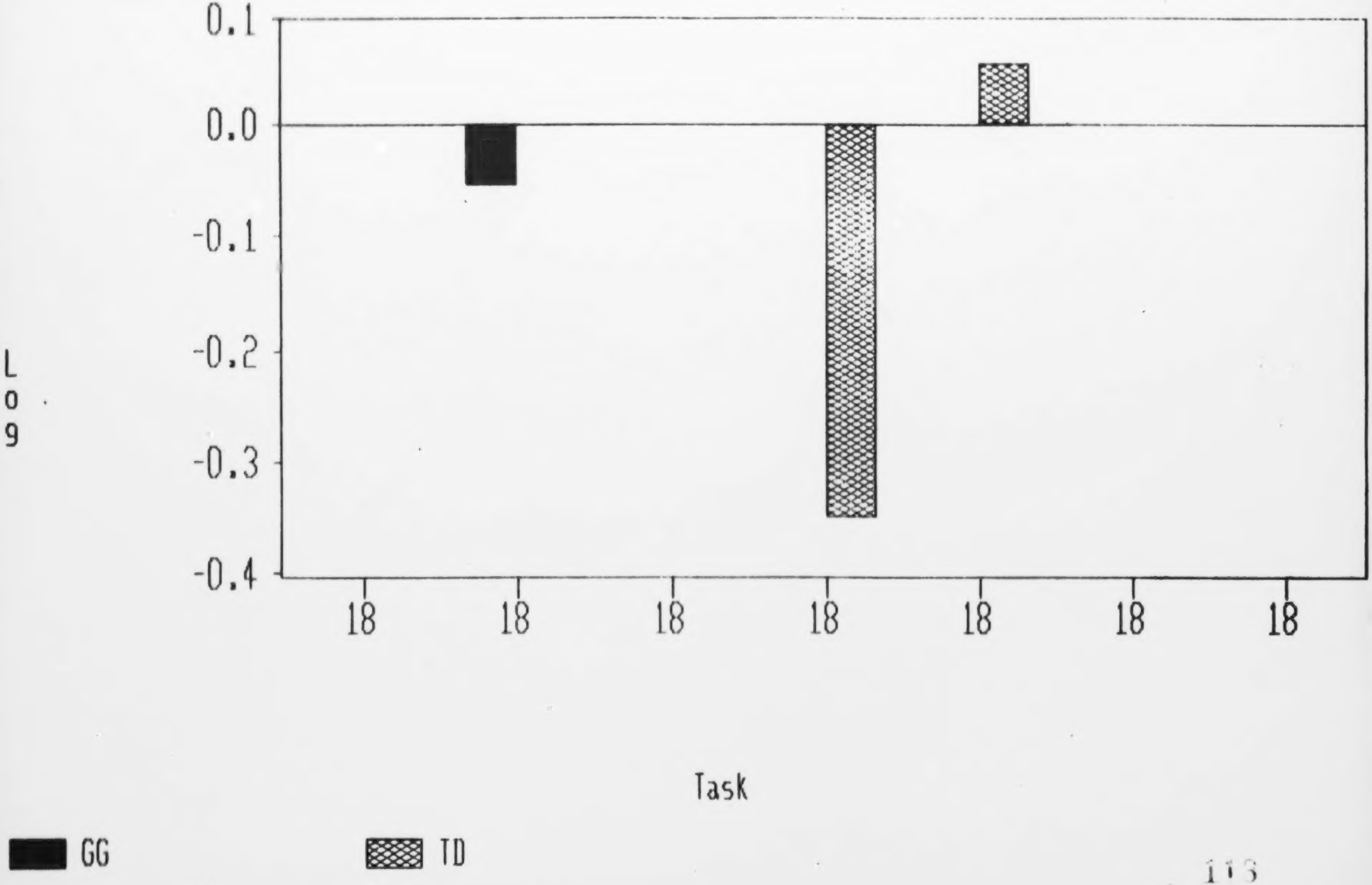


Subject Seven, Perfromance by Pairs

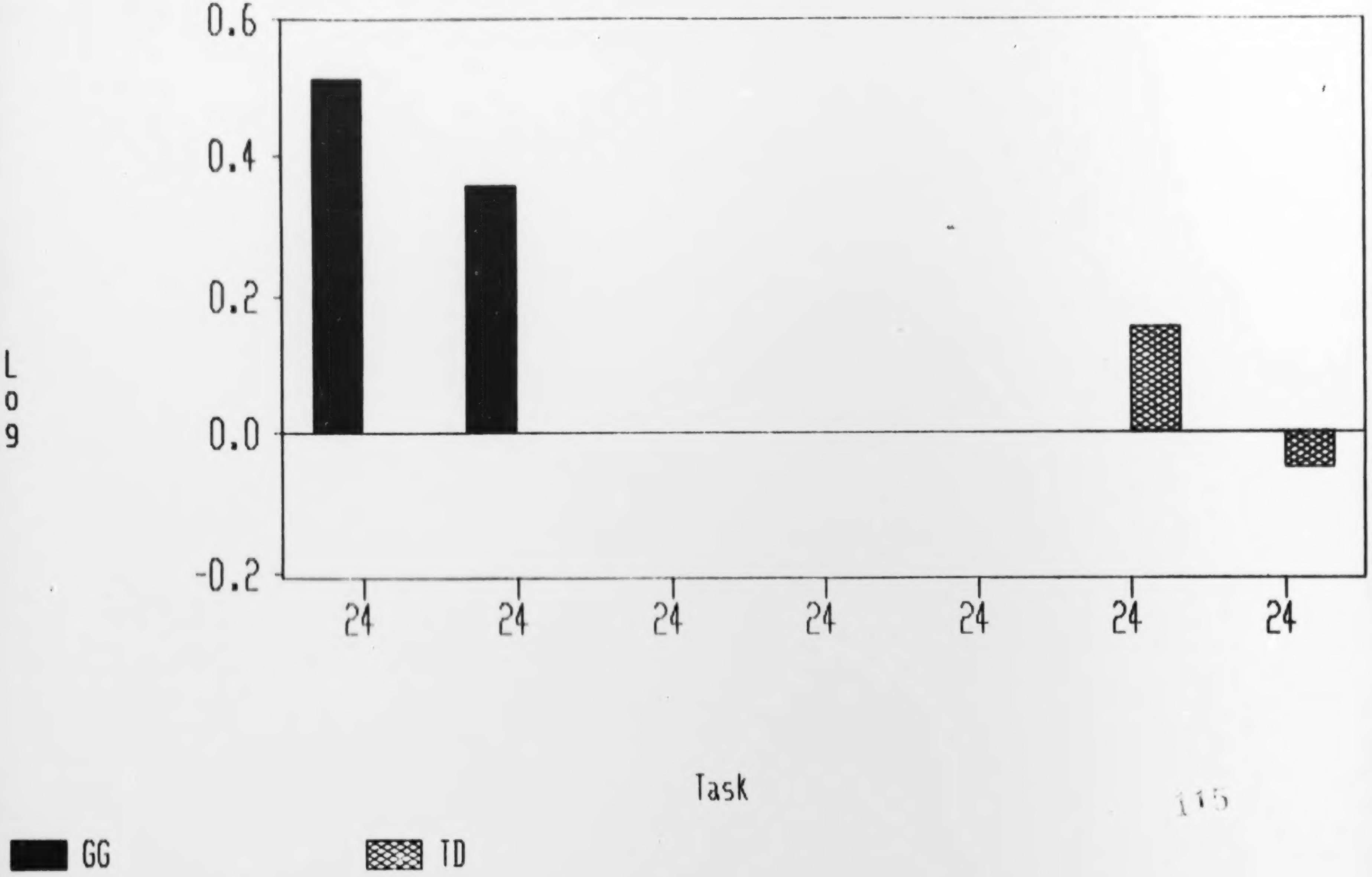
Perforamnce on Tasks in Pair Two



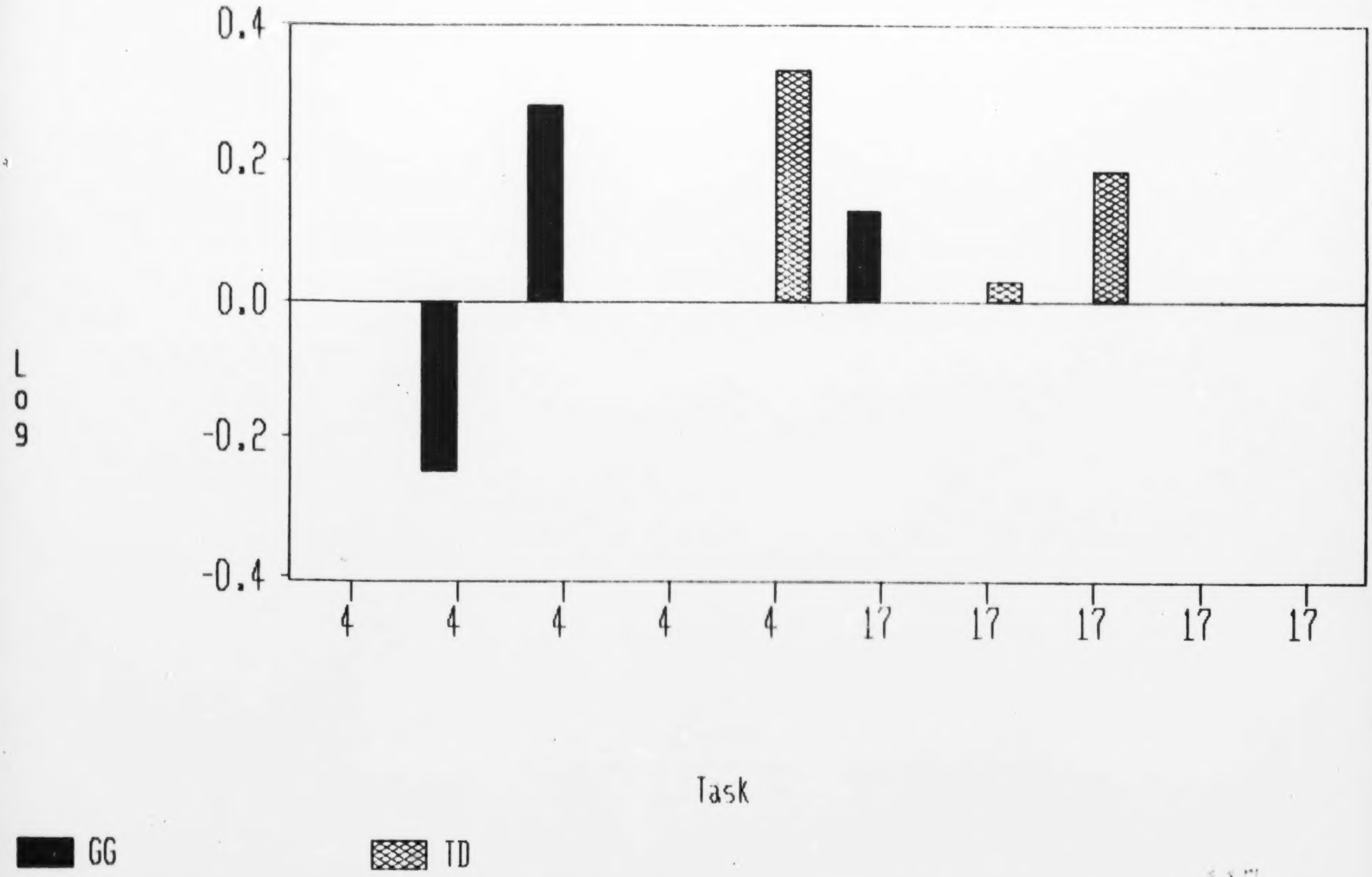
Performance on Task Eighteen, Pair Three



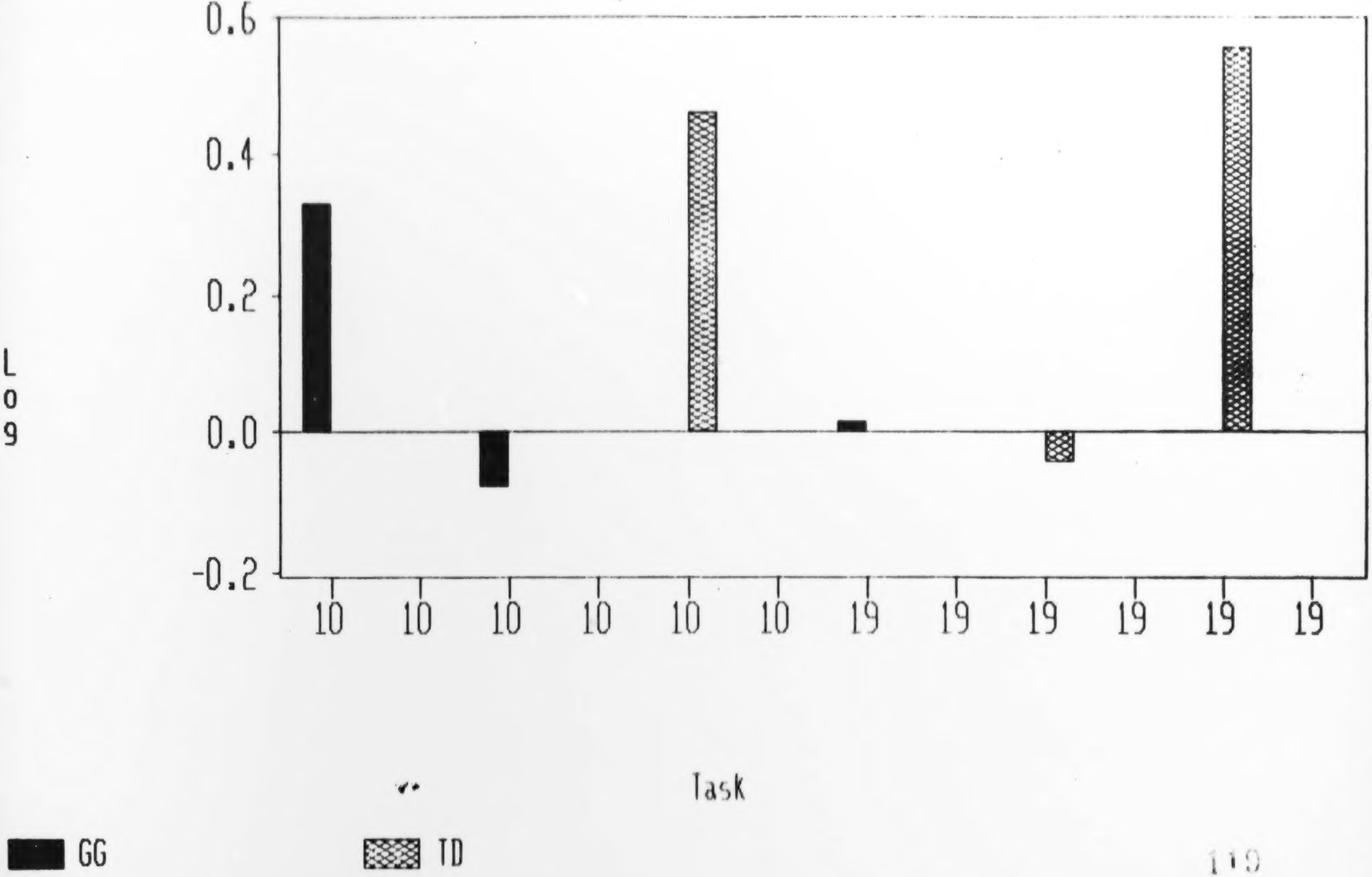
Performance, Task Twenty-four, Pair Three

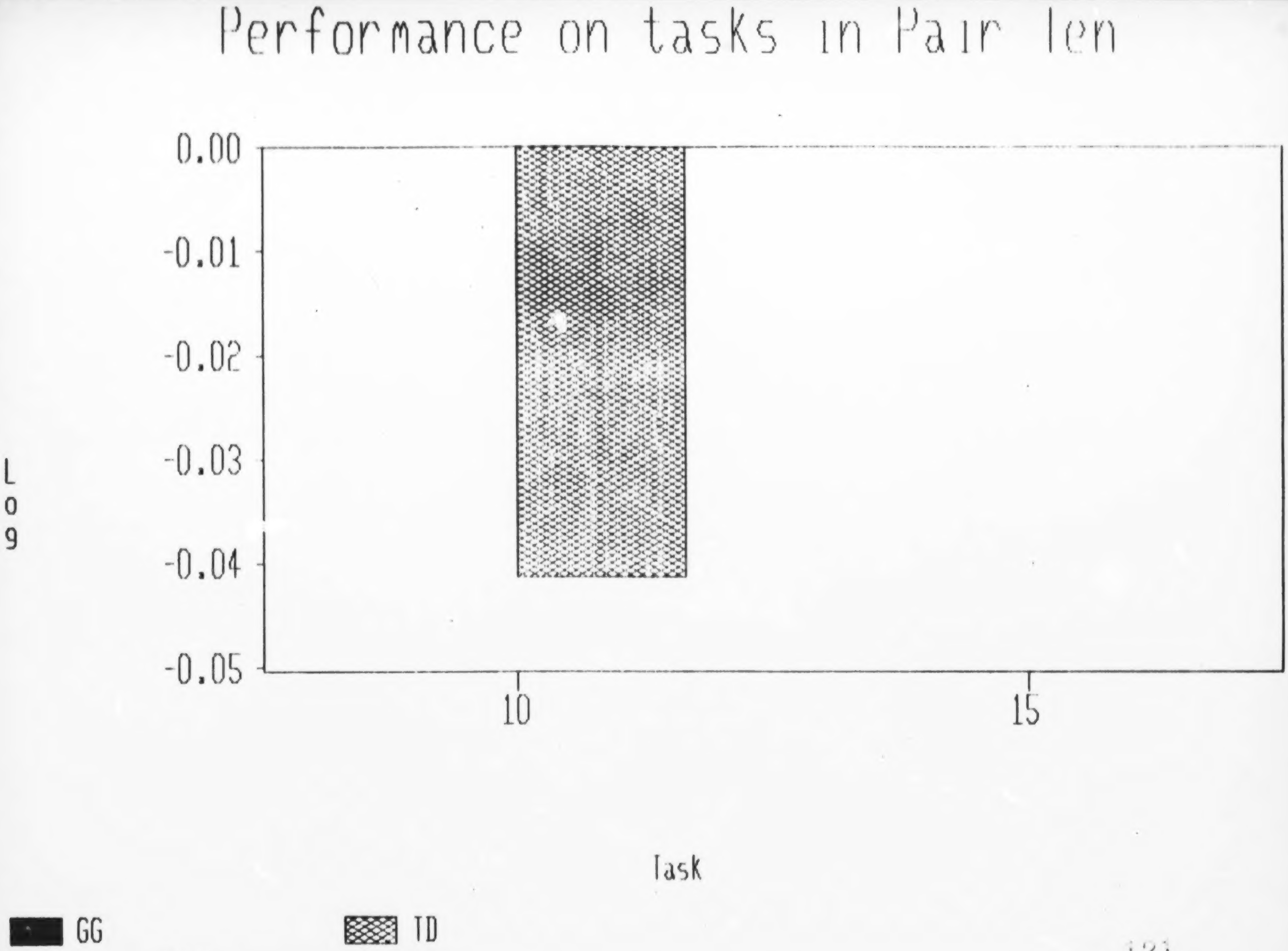


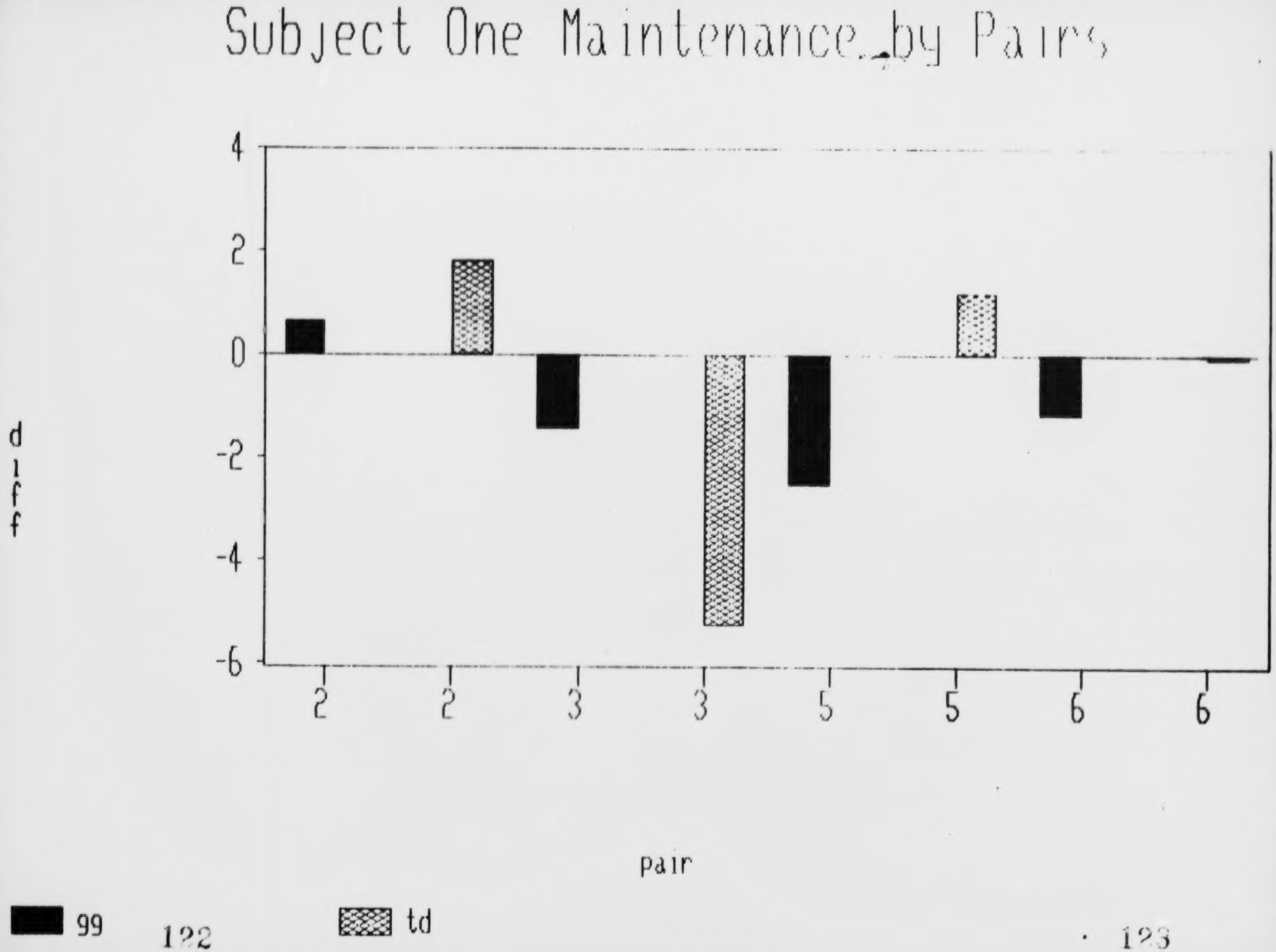
Performance on Tasks in Pair Five

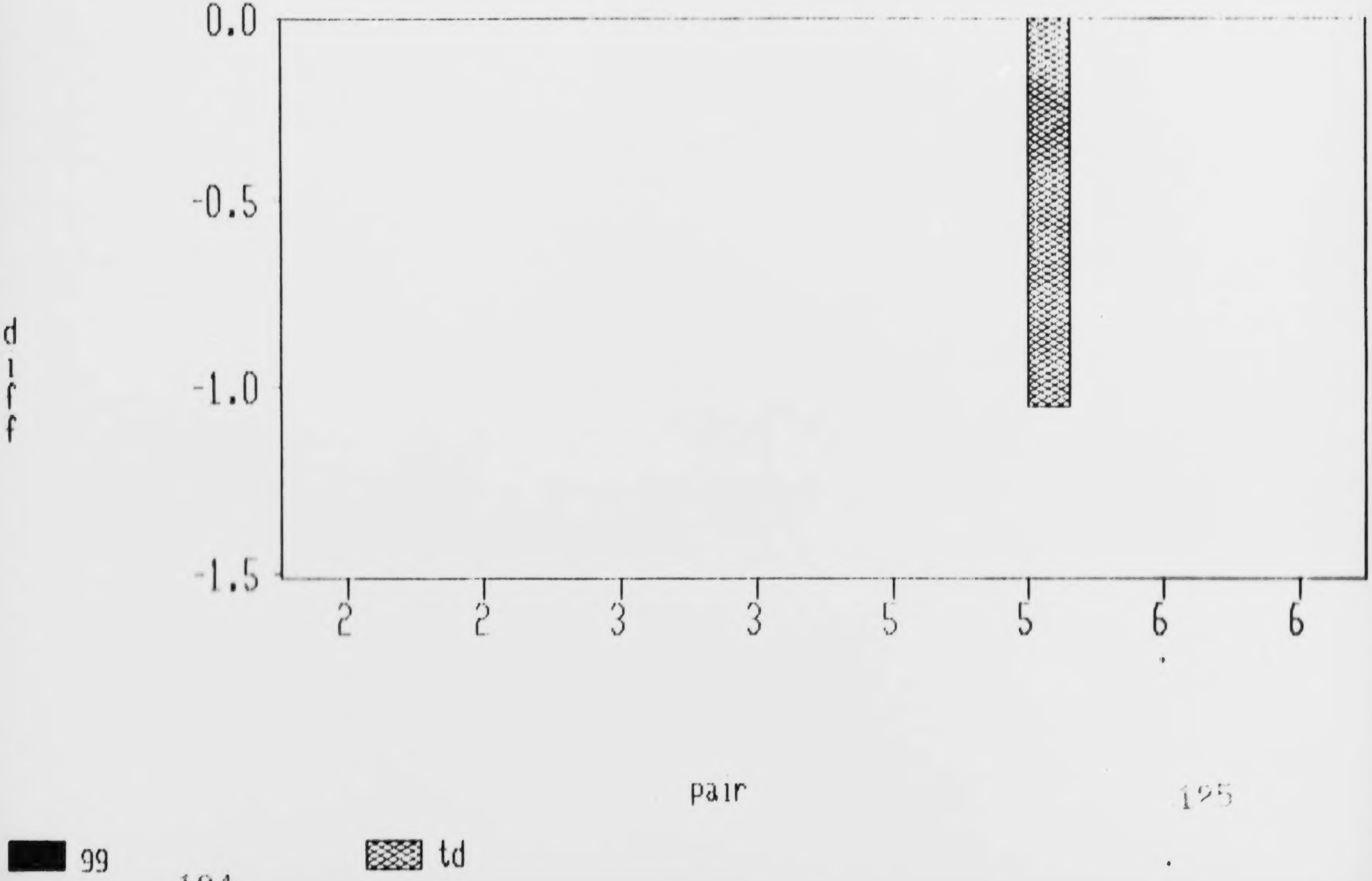


Performance on Tasks in Pair Six

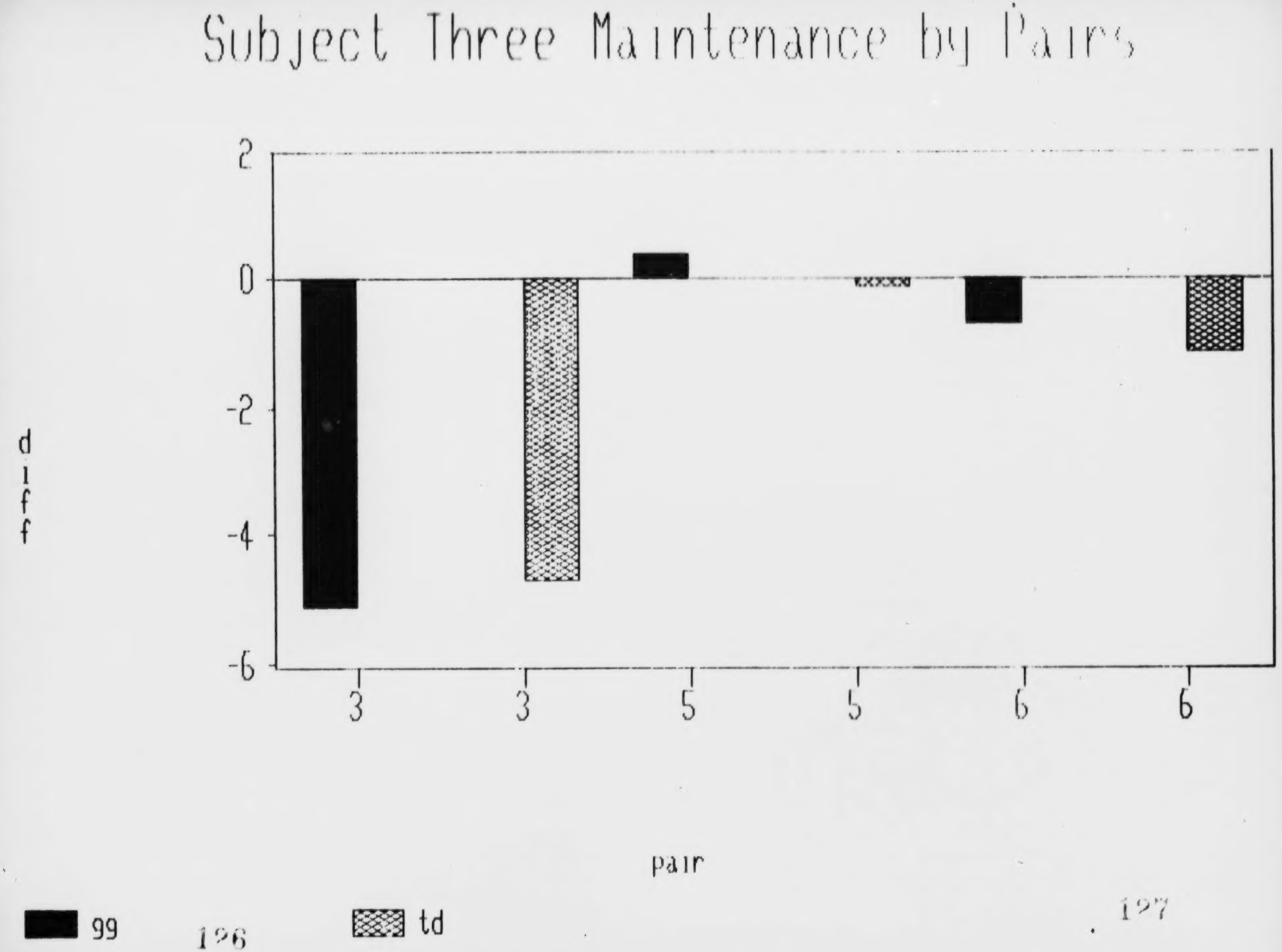



Performance on tasks in Pair Ten
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
Log
10
15
Task
GG
TD


Subject One Maintenance by Pairs

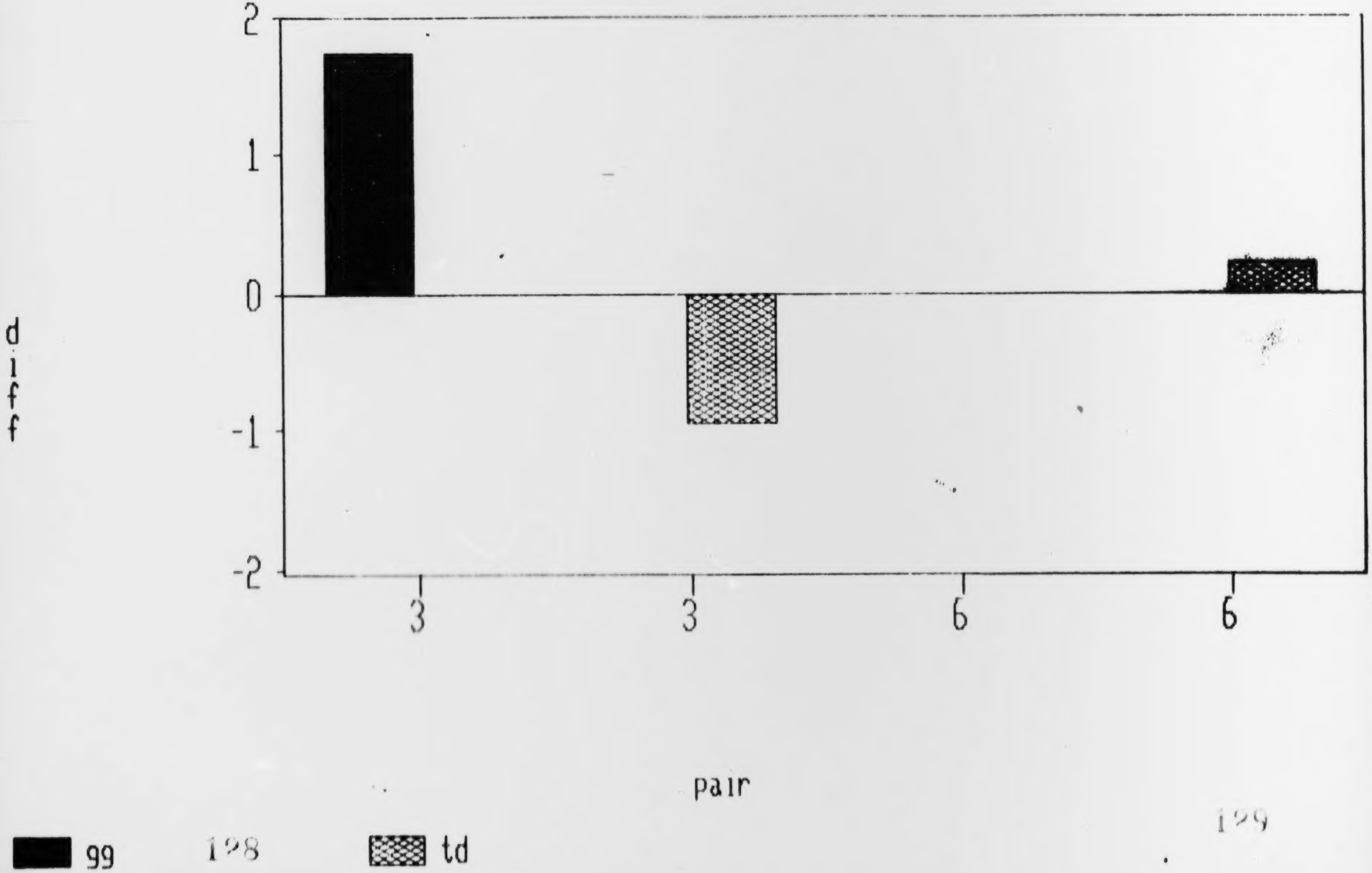


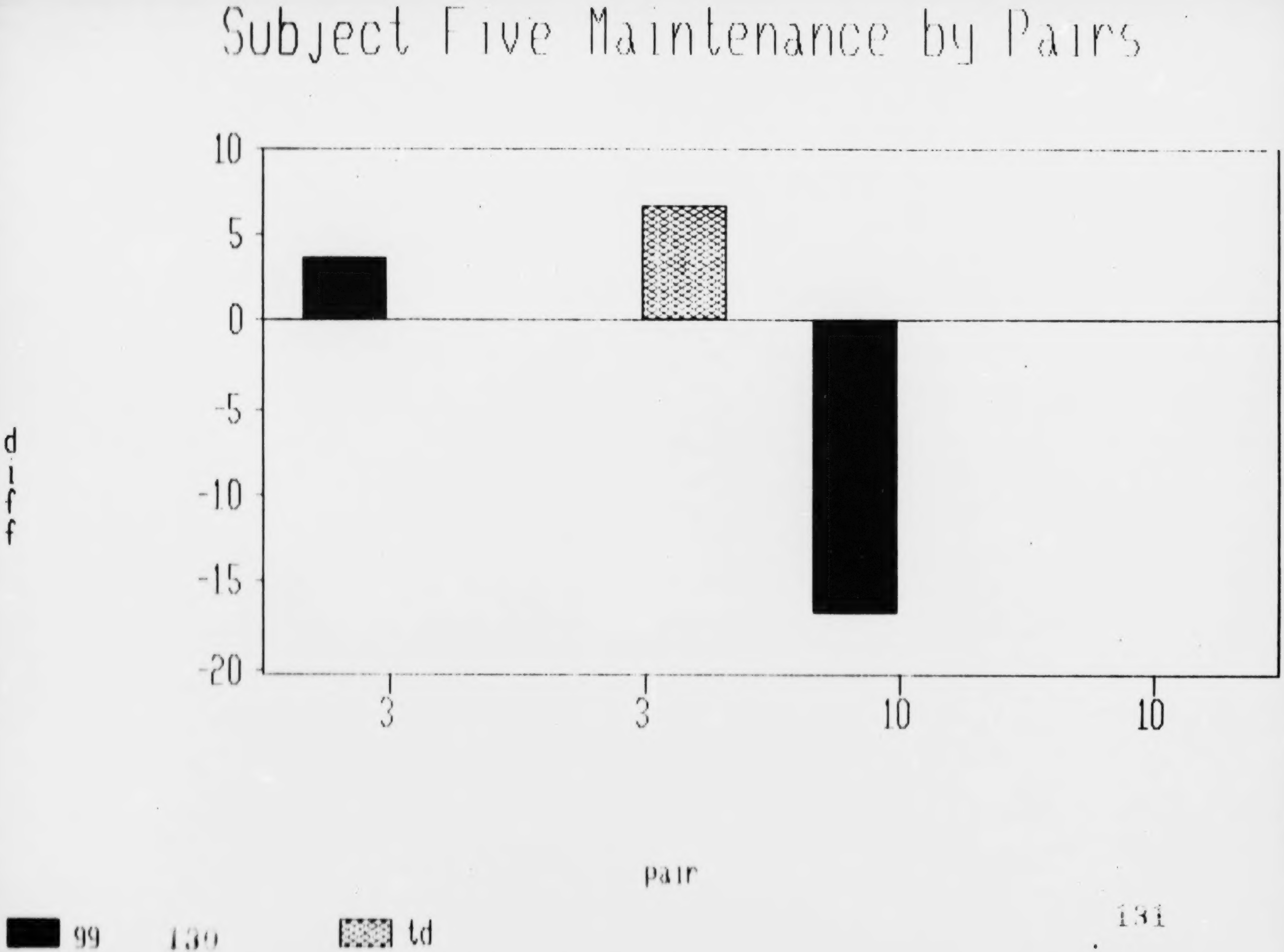
Subject Two Maintenance by Pairs



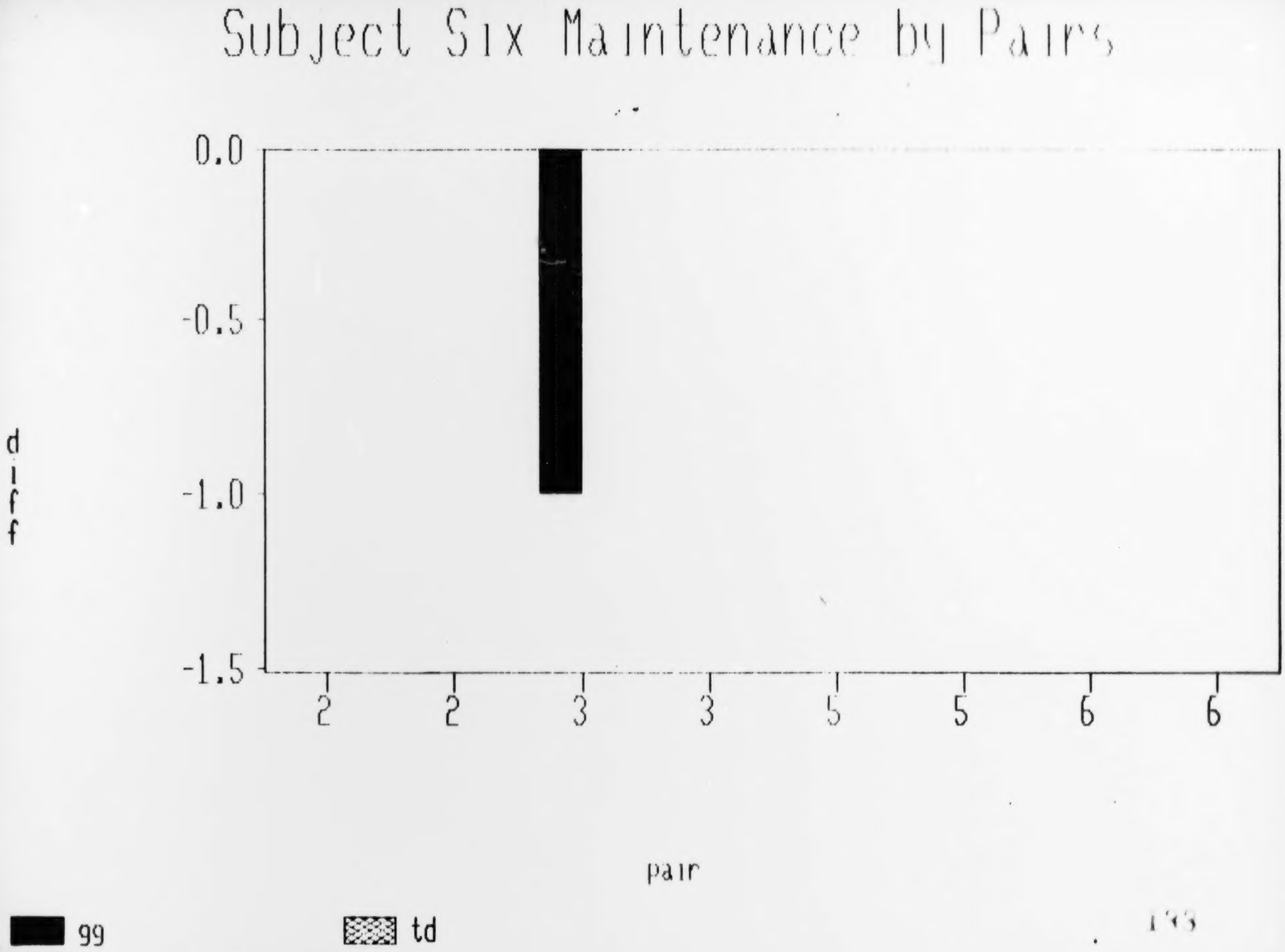
Subject Three Maintenance by Pairs

Subject Four Maintenance by Pairs





Subject Five Maintenance by Pairs


Subject Six Maintenance by Pairs
0.0
-0.5
-1.0
-1.5
diff
2
2
3
3
5
5
6
6
pair
■ gg
▨ td

APPENDIX 1

Appendix 1

Descriptions of 18 TPS Items

Item #	Description
15	Materials: a block with a red stripe and rubber cap. Task: turn the block over and put the cap on top.
10	Materials: nut and bolt. Task: screw the nut onto the bolt.
19	Materials: two 1-1/2 inch right angles. Task: form a box with the right angles.
17	Materials: broom clip and card with outline of broom clip. Task: place the clip on the card so that it matches the outline.
4	Materials: large bolt embedded in acrylic plastic and a lock nut. Task: place nut on bolt, spiked side up, and screw it on.
3	Materials: 2 inch sq. card and 1 inch sq. block. Task: place the card on top of the block.
22	Materials: acrylic base with two posts on it and two rubber washers. Task: to place the washers on the post, one with small end up, the other with small end down.

13 Materials: bolt in acrylic base, with red line 1/2 inch from the top, and a wing nut. Task: place wing nut on bolt and screw on so nut touched red line.

24 Materials: one solderless connector and a block with three different sized holes. Task: place the connector in the smallest hole.

18 Materials: Two 1-1/2 inch metal right angles, each painted red on one end. Task: place the angles so that the red ends touch.

21 Materials: one small brass roller, acrylic base, with two posts, and one pair of tweezers. Task: place the roller on the post with the tweezers.

16 Materials: one zip lock plastic bag, closed. Task: open the bag.

8 Materials: one paper clip an one 2-1/2 inch cardboard square. Task: place the paperclip on the cardboard square. Task: place the paperclip on the cardboard square.

5 Materials: red block with one side painted red. Task: turn the block red side up.

11 Materials: card with a red stripe and a block of acrylic with a groove on the bottom. The top of the acrylic block has a red stripe on it. Task: place the card under the block so that the stripes are in a straight line.

12 Materials: a small jar lid and a penny. Task: place the lid on the penny.

20 Materials: four different colored boxes with lids removed. Task: place the lids on the correct colored boxes.

1 Materials: one 6 inch piece of copper wire. Task: bend the copper wire to at least a 30 degree angle.

APPENDIX 2

Subject	Condition	Pair	Task	Correct Slope	Error Slope
S1	TD	5	4	X2.12	-1.34
S1	GG	5	17	X1.35	-1.75
S1	TD	6	19	-1.12	-1.13
S1	GG	6	10	X2.13	X1.0
S1	TD	1	20	X1.53	-1.38
S1	GG	1	12	-2.19	-1.07
S1	TD	2	5	X1.70	X1.0
S1	GG	2	9	X2.79	-1.21
S1	TD	4	17	X1.06	-1.21
S1	GG	4	22	X1.06	X1.41
S1	TD	3	18	-2.26	X2.26
S1	GG	3	24	X3.21	-1.26
S1	TD	3	18	X1.27	X1.03
S1	GG	3	24	X1.17	-1.03

Subject	Condition	Pair	Task	Correct Slope	Error Slope
S2	TD	5	17	X1.06	X1.17
S2	GG	5	4	X1.0	X1.0
S2	TD	6	19	X1.0	X1.0
S2	GG	6	10	X1.0	X1.0
S2	TD	1	20	X1.0	X1.0
S2	GG	1	12	X1.0	X1.0
S2	TD	2	9	X1.0	X1.0
S2	GG	2	5	-1.05	X1.0
S2	TD	4	22	X1.0	X1.0
S2	GG	4	13	X1.0	X1.0
S2	TD	3	24	X1.0	X1.0
S2	GG	3	18	X1.0	X1.0
S2	TD	3	24	X1.0	X1.0
S2	GG	3	19	X1.0	X1.0

Subject	Condition	Pair	Task	Correct Slope	Error Slope
S3	TD	4	22	X10.32	-2.51
S3	GG	4	13	-1.45	-1.12
S3	TD	1	12	X1.12	X1.0
S3	GG	1	20	X2.15	X1.05
S3	TD	6	19	X3.57	X1.0
S3	GG	6	[illegible]	-1.21	-1.14
S3	TD	8	5	X1.83	-1.06
S3	GG	8	[illegible]	X1.0	X1.0
S3	TD	5	[illegible]	X1.53	X1.04
S3	GG	5	4	-1.79	X1.16
S3	TD	3	18	X1.14	X1.0
S3	GG	3	24	X2.26	X1.0
S3	TD	3	18	X1.54	X1.0
S3	GG	3	24	X1.61	-1.33

Subject	Condition	Pair	Task	Correct Slope	Error Slope
S4	TI	8	21	X1.06	-1.33
S4	GG	8	5	X6.64	X1.38
S4	TI	7	11	X1.0	X1.0
S4	GG	7	12	X1.0	X1.56
S4	TI	6	10	X2.85	X1.03
S4	GG	6	15	-1.04	X2.69
S4	TI	4	22	X1.09	-2.09
S4	GG	4	13	-1.05	-1.07
S4	TI	5	4	-1.07	X2.26
S4	GG	5	7	X6.64	-1.06
S4	TI	3	18	X1.0	X1.0
S4	GG	3	24	X1.0	-1.31
S4	TI	3	18	-1.01	X1.33
S4	GG	3	24	-1.01	-1.12

Subject	Condition	Pair	Task	Correct Slope	Error Slope
SE	TD	7	11	X62.19	-22.74
SE	GG	7	12	-1.06	X10.91
SE	TD	9	4	X1.21	X1.06
SE	GG	9	3	X1.76	X1.0
SE	TD	10	10	-1.1	X1.1
SE	GG	10	15	X1.0	X1.0
SE	TD	8	21	X2.3	-5.19
SE	GG	8	8	-1.54	-1.04
SE	TD	3	14	X1.43	X1.0
SE	GG	3	16	-1.13	X1.0
SE	TD	7	24	-1.1	X1.0
SE	GG	7	18	-1.10	X1.01

Subject	Condition	Pair	**Task**	**Correct Slope**	**Error Slope**
Sa	TI	5	17	X1.0	X1.0
Sa	GG	5	4	X1.92	X1.92
Sa	TI	6	10	X1.0	X1.0
Sa	GG	6	19	X1.0	X1.0
Se	TI	1	12	X11.71	X11.71
Se	GG	1	20	X1.0	X1.0
Se	TI	2	8	X1.0	-9.79
Se	GG	2	5	X1.0	X1.0
Se	TI	4	13	X1.0	X1.0
Se	GG	4	22	X1.0	X1.0
Se	TI	3	18	X1.0	X1.0
Se	GG	3	24	X1.0	X1.0
Se	TI	3	18	X1.0	X1.0
Se	GG	3	24	X1.0	X1.0

Subject	Condition	Pair	Task	Correct Slope	Error Slope
S7	TD	5	17	X1.0	X1.0
S7	GG	5	4	X1.0	X1.0
S7	TD	6	19	X1.0	X1.0
S7	GG	6	10	X1.0	X1.0
S7	TD	1	20	X1.0	X1.0
S7	GG	1	12	X1.0	X1.0
S7	TD	2	5	X1.0	X2.7
S7	GG	2	3	X1.0	X1.0
S7	TD	4	22	X1.0	X1.0
S7	GG	4	12	X1.0	X1.0
S7	TD	3	24	-1.13	X2.77
S7	GG	3	18	X1.0	X1.0
S7	TD	3	24	X1.0	-1.01
S7	GG	3	18	X1.0	X1.0